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WASHINGTON STATE AGRICULTURAL COLLEGE
AND
SCHOOL OF SCIENCE.

EXPERIMENT STATION,

PULLMAN, WASHINGTON.

Bulletin 46.

Puyallup Station.

Potato Blight and its Treatment.

By David A. Brodie.

1901.

All bulletins of this station sent free to citizens of the state on application to the
Director.

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POTATO BLIGHT AND ITS TREATMENT.

BY D. A. BRODIE.

Owing to the very general occurrence of potato blight in Western Washington and the damage caused by it during the past two years, not only in preventing the proper growth and development of the tubers, but in causing them to rot during the winter, or rendering them unfit for planting in the spring, it is thought advisable to give to the public the results of our experiments in treating the disease here during the past season. So far as known to the writer very little has been done toward preventing its ravages in the state.

NATURE OF THE DISEASE.

Potato blight is a general term applied to certain fungous diseases which attack the leaves, stems, and in some cases the tubers, of the potato. At least two of these diseases are found on potatoes here but the late blight, caused by the fungus, *Phytophthora infestans*, DEBARY, is by far the most destructive. It is to this disease that the following experiments apply, although the same treatment is effective in the so-called early blight.

Many people have the erroneous idea that a fungus is caused by the sting of some insect, and it therefore becomes necessary to explain as clearly as possible the nature of a fungus.

A fungus is a low form of plant life distinguished from all other forms by two characters, viz: 1st, it contains no green coloring matter as do ordinary plants, and 2nd, it reproduces by spores,

very minute bodies which correspond in function to the seeds of higher plants.

The absence of green coloring matter deprives it of the power of manufacturing its own food from the crude elements in the air and soil, as all green colored plants do. Consequently it must depend on having its food prepared for it. We find fungi (singular fungus) therefore, growing wherever organic matter is present which will serve as food, and where the conditions of heat

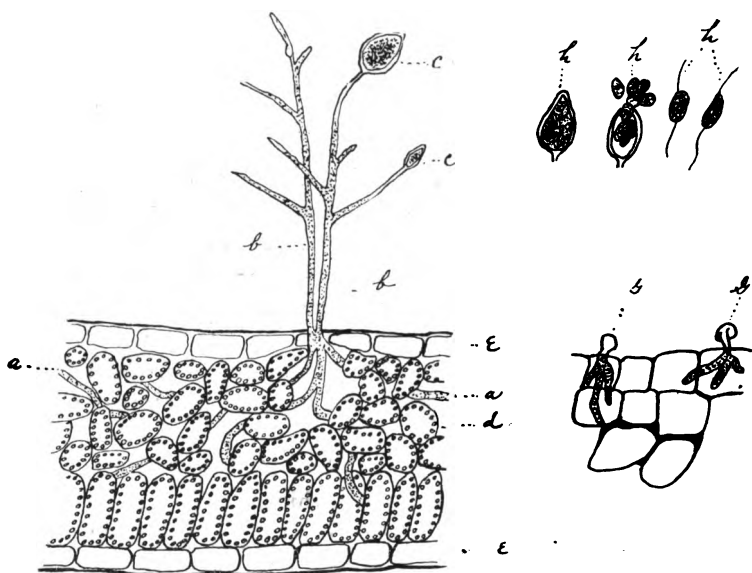


FIG. 1—*Phytophthora infestans*, DEBARY, highly magnified.—A cross-section of a small portion of a potato leaf. a—mycelium; b—spore-bearing branches, conidiophores; c—spores; d—cells of the potato leaf; e—epidermis of the leaf; g—germinating spores, showing how the germ-tubes penetrate the cells of the leaf; h—spore subdividing into swarm-spores; hi—swarm-spores escaping; hii—mature swarm-spores. Modified after Strasburger & DeBary.

and moisture are favorable. Many fungi live on dead plant and animal matter and are known as saprophytes. Among these may be classed some of the toadstools, mushrooms, puffballs, common mould, etc. Others live on the tissues of living plants or animals and are known as parasites. To these belong the fungus diseases of our cultivated crops, such as potato blight, apple scab, mil-

dews, rust and smut. Still others are parasitic at one period in life and are saprophytic at another.

When the spore of a fungus falls in a favorable place to germinate, it sends out a delicate germ tube, which grows into a long, thread-like filament called a hypha. By branching and continued growth a mass or network of these hyphae (singular hypha) is formed, known as the mycelium or spawn. This is the vegetative portion of the fungus and serves the same purpose as the roots, stem, branches, and leaves of the higher plants, viz: to fasten the fungus to whatever it happens to grow on and for the absorption of food.

The spores are borne for the most part on branches which project from the mycelium. They are usually produced in great numbers, thousands being often borne upon a single plant.

Many fungi produce two kinds of spores commonly known as summer and winter spores. The summer spores are capable of germinating at once and serve to spread the fungus rapidly during the summer. The winter spores lie dormant during the winter and germinate in the spring, their function being to tide the plant over an unfavorable period.

As before stated most of our pests belong to the parasitic fungi, so by describing the habits of the potato blight we may obtain a fairly good idea of the nature of this class of fungi.

In the potato blight only the summer spores are known to occur. These are borne on branches which project through the stomata (breathing pores) of the leaf. These may germinate at once, or if the weather is very damp the contents of the spore may divide into several "swarm spores" which swim about in the water and are also capable of germinating at once. The germ tube pierces the epidermis and penetrates the cells of the leaf. Here by repeated branching it forms a mycelium, and by this means steals its food from the store which the host (the plant on which the parasite grows) has prepared for its own use. In a short time, minute branches are sent out from the mycelium through the stomata, on which the spores are formed as above described. See Fig. I. These are formed in great abundance, and make fresh inroads on the surrounding tissues of the same leaf or are carried by the rain to other leaves of the same plant, or blown

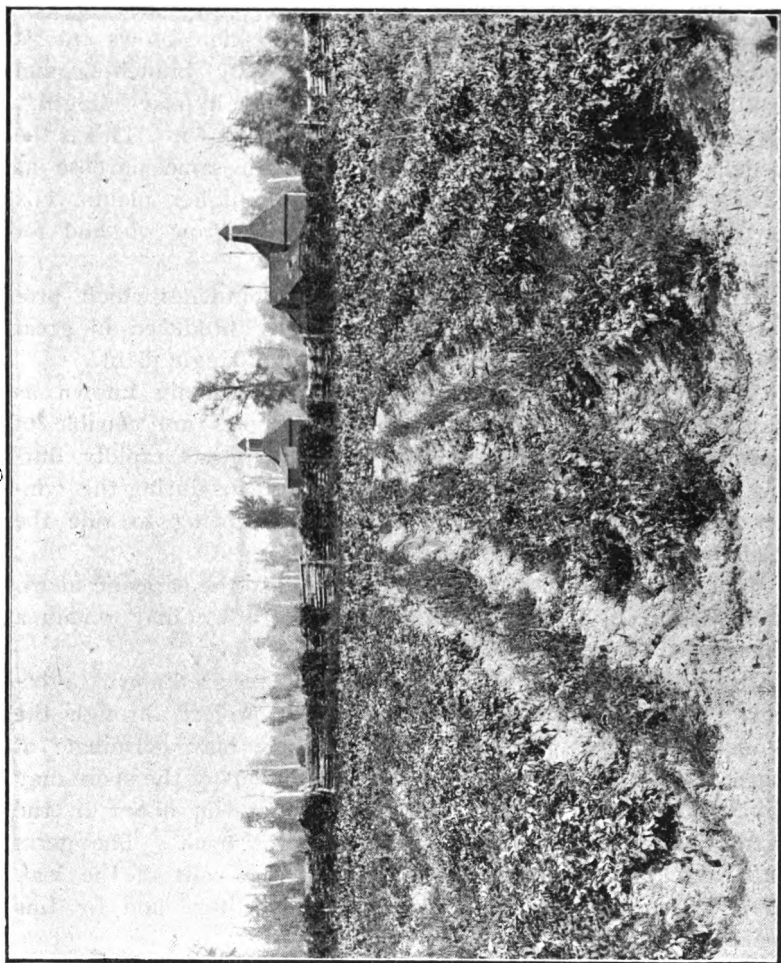


FIG. 2.--Showing the effect of the Bordeaux Mixture on potato blight.*

*The centre row was sprayed once, July 17th; the second row on the right was sprayed once, July 3rd; the 2nd and 3rd on the left, and the 3rd and 4th on the right received two applications, while the 1st on each side of the center row received no treatment at all.

by the wind to healthy leaves of other plants. So the disease spreads, especially in moist warm weather.

Toward the end of the season the mycelium grows downward through the stems of the plant into the tubers, where it remains over winter. As soon as the potato begins to grow in the spring the mycelium of the fungus grows up through the tissues and matures the first summer spores of the season.

PRINCIPLES OF SPRAYING.

As most fungi live within the tissues of the host plant, and only the spores are exposed, it is readily seen that the treatment of the main body of the fungus is practically impossible as whatever would penetrate so far as to injure the fungus must at the same time injure the host plant. Consequently we look to the spore stage to find a vulnerable place to attack it, as the spore is the only part of most fungi that ever appears outside the epidermis.

It has been demonstrated many times that spores of fungi will not germinate in the presence of certain chemicals, such as copper salts, and on account of its cheapness as well as its effectiveness, copper sulphate (blue stone) is used most extensively.

Some plants are so tender and sensitive that the pure blue stone can not be used without injury, and for that reason the Bordeaux mixture, a combination of blue stone and lime, is used. The lime neutralizes the copper sulphate and renders it perfectly harmless to most plants, without destroying its usefulness as a fungicide. It also possesses the quality of being very adhesive. By coating the leaf with a thin film of the Bordeaux before the fungus has had a chance to gain a foot-hold, any spores that may be carried to it come in contact with the copper which prevents its germinating.

PLAN OF THE EXPERIMENT.

With a view of testing the value of the Bordeaux mixture on potato blight, a plat 4x18 rods was selected on sandy bottom land which had been in cultivation for many years. The soil was not uniform and the crops and fertilizers used during preceding years were not the same throughout. To eliminate this difficulty the yields

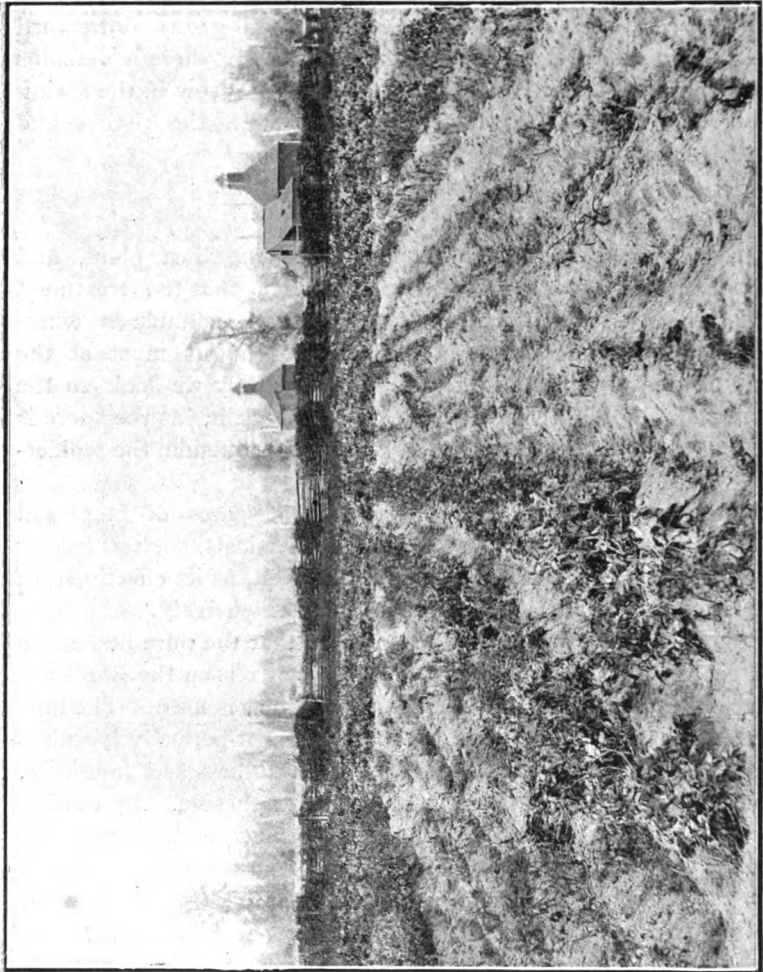


FIG. 3.—Same as Fig. 2, taken a month later, showing the work of the cutworm.*;

*The two prominent rows on the left of the picture received two applications of the Bordeaux Mixture, and are untouched, while the others, including those receiving only one application, are eaten to the ground.

were estimated in couplets, that is, two adjoining rows, one sprayed, the other not, were taken together. This was done at regular distances throughout the field, consequently the figures obtained from the rows in different parts of the field vary considerably. The result in every case was an increased yield in rows treated. All the rows were exactly four rods long, and ran crosswise of the plat.

Slight indications of the blight began to appear about July 1st, and on July 3rd every alternate three rows were sprayed with the Bordeaux mixture. The disease continued to spread over the untreated portions until July 17th when the field was again sprayed as follows:

Two rows in each plat already sprayed were treated again, and the 3rd row was left to try the effect of one treatment when applied early. The middle row in each of the plats not sprayed July 3rd was also sprayed at this time to try the effect of one treatment when applied after the blight had advanced considerably. Thus, in every six rows throughout the field were two rows not treated, two rows treated twice and two treated once, one early and the other two weeks after the disease appeared.

It may be stated here that the result of the single treatment was very much in favor of the early application but in neither case was the effect as well marked as where two applications were made. See Fig. II.

An incident occurred during the test which cannot be overlooked.

During the latter part of July, this section of the country was overrun by a species of the cutworm family *Peridroma saucia*, which, though not so destructive on the station as in portions of the surrounding country, did some damage in parts of this particular field. It was noticed that the rows which had received two applications of Bordeaux were left untouched by the insect, while the leaves and stems of the untreated rows were totally destroyed. In other words the blight had not quite completed its work before the cutworm came in and hastened the total destruction. See Fig. III.

It is believed that the difference in the yields of some of the sprayed and unsprayed rows was due in a measure to the work of

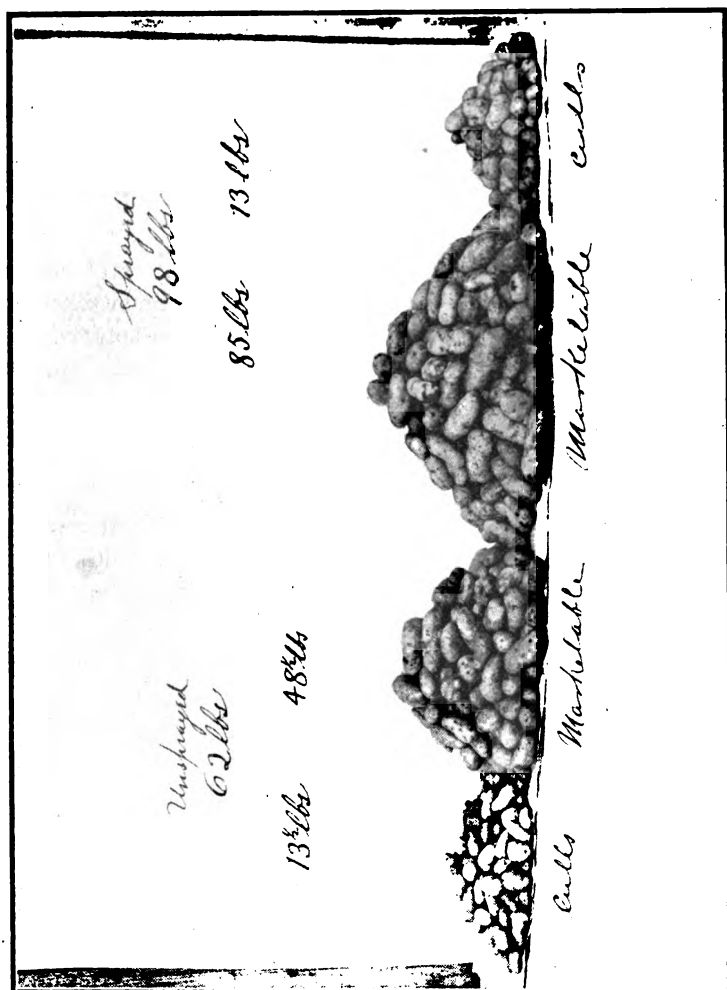


FIG. 4.—Showing the difference in the yield of sprayed and unsprayed rows.

the cutworm, as the assimilation of plant food would, to a limited extent, have gone on for some time longer had the insect not cut it completely off.

The following table gives the comparison of twelve rows which were sprayed twice, with twelve unsprayed, the two which were adjacent in the field being placed opposite each other in the table:

SPRAYED.			UNSPRAYED.		
Marketable.	Culls.	Total.	Marketable.	Culls.	Total.
LBS.	LBS.	LBS.	LBS.	LBS.	LBS.
64	10	74	60¾	10	70¾
62½	12½	75	56½	13	69½
60	13	73	54	9	63
82	12	94	52	9	61
69	12	81	39	9	48
72	9	81	59	11	70
65	9½	74½	53½	8¾	62¼
85	13	98	48½	13½	62
67	13	80	44	16	60
65	11	76	46	15	61
80	13	93	55	14	69
86	16	102	57	14	71
857½	144	1001½	625¼	142¼	767½

The average increase in the yield of marketable potatoes in the twelve sprayed rows, over that of the unsprayed rows is nearly 37 per cent. However, as before stated, the increase may not have been so marked if the cutworms had not appeared, but as the photograph taken before the cutworms appeared shows, the difference between the sprayed and the unsprayed rows is clearly marked.

WHEN TO SPRAY.

So much depends upon the weather conditions for the development of the potato blight that no set time can be given for its appearance. Last year it appeared about the 1st of July, and the year before somewhat later.

When it first appears, small mildewy spots appear on the under side of the leaves, then dead, brown spots appear. When once

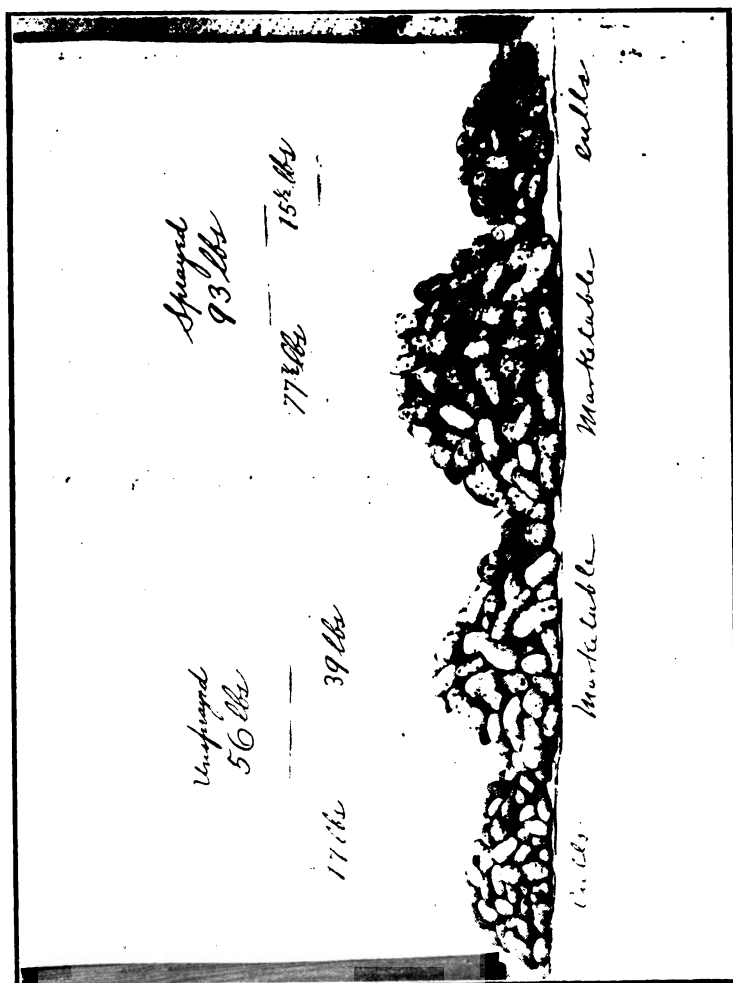


FIG. 5.—Showing the difference in the yield of sprayed and unsprayed rows.

started the disease spreads very rapidly and has been known to spread over an entire field in one or two days. Soon the leaves and stems are reduced to a decaying mass which emits a very disagreeable odor. From this it is plain that as soon as the disease is developed no time should be lost in going to work.

Undoubtedly the *best* plan would be to spray once quite early, say about the middle of June in order to be sure of heading off the disease. This should be repeated every two weeks to insure success, as a great deal depends on keeping the plants safely guarded against the attacks of the spores.

In most cases two applications would suffice but three are recommended. In any case the first application *must* be done before the disease gets a foothold. This is plainly illustrated in Fig. III. The center row in the picture was not sprayed until July 17th and the difference between it and the unsprayed rows on either side of it is very slight, while on the right of the picture, the nearest of the sprayed rows was treated on July 3rd, and the difference is quite marked. In this case the leaves were protected so that the spores could not find a favorable place to grow, while in the other the germ tubes of the spores had already entered the leaf, and the spray being applied too late was ineffective.

HOW TO MAKE BORDEAUX.

Dissolve 4 pounds of copper sulphate in 25 gallons of water in a *wooden* vessel. In a separate vessel put 6 pounds of quick lime and add water slowly until it is completely slaked then dilute to 25 gallons and stir thoroughly. The bluestone solution and the mixture of lime and water should then be poured together slowly into a third vessel; it is then ready to be strained into the spray barrel. In order to get the best results the mixture should be used the same day it is made.

To dissolve the bluestone it is best done by suspending it in the water in a coarse sack or something of the kind, for about three or four hours or over night. The reason for this is that as the bluestone dissolves it sinks to the bottom, so by keeping the undissolved material near the surface it dissolves faster than it would in the more nearly saturated solution at the bottom.

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WASHINGTON STATE AGRICULTURAL COLLEGE
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EXPERIMENT STATION,

PULLMAN, WASHINGTON.

Bulletin 47.

Department of Botany and Zoology.

THE VARIEGATED CUTWORM.

By R. W. Doane and D. A. Brodie.

1901.

All bulletins of this station sent free to citizens of the state on application to the
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THE VARIEGATED CUTWORM.

(*Peridroma saucia* Hubner.)

BY R. W. DOANE AND D. A. BRODIE.

Early in July, 1900, the farmers and orchardists of Western Washington were considerably alarmed over the great number of cutworms that appeared and attacked nearly all kinds of vegetation. By July 15th the outbreak had become so general, and the number of cutworms was so great, that it seemed as if they would carry everything before them, for they had by this time literally become an invading army, marching on from garden to garden, from field to field, from orchard to orchard, eating every green plant that came in their path. They seemed to come from every place, and to march in every direction, although the principal movement was from southwest to northeast. A field or garden seemingly free from the pest one day might be wholly overrun within the next two or three days. The numbers kept on increasing until about July 25th, when they seemed to be doing the maximum amount of damage. At this time the number of worms in an infested area was almost inconceivable, there being hundreds of them to the square yard, and a person could not walk about without crushing a number at each step. Many gardens were wholly destroyed; potatoes, cabbage, lettuce, turnips, onions, carrots, asparagus, rhubarb, tomatoes, etc., etc., were stripped clean in a short time.

In response to an urgent call from some of the fruit growers we visited farms devoted particularly to the raising of small fruits. Here we found the raspberries and blackberries suffering most, although everything else was in a sorry plight. Hundreds of worms would be found in every berry bush, eating the leaves, fruit and tender canes.

Many young orchard trees were completely ruined, for, after

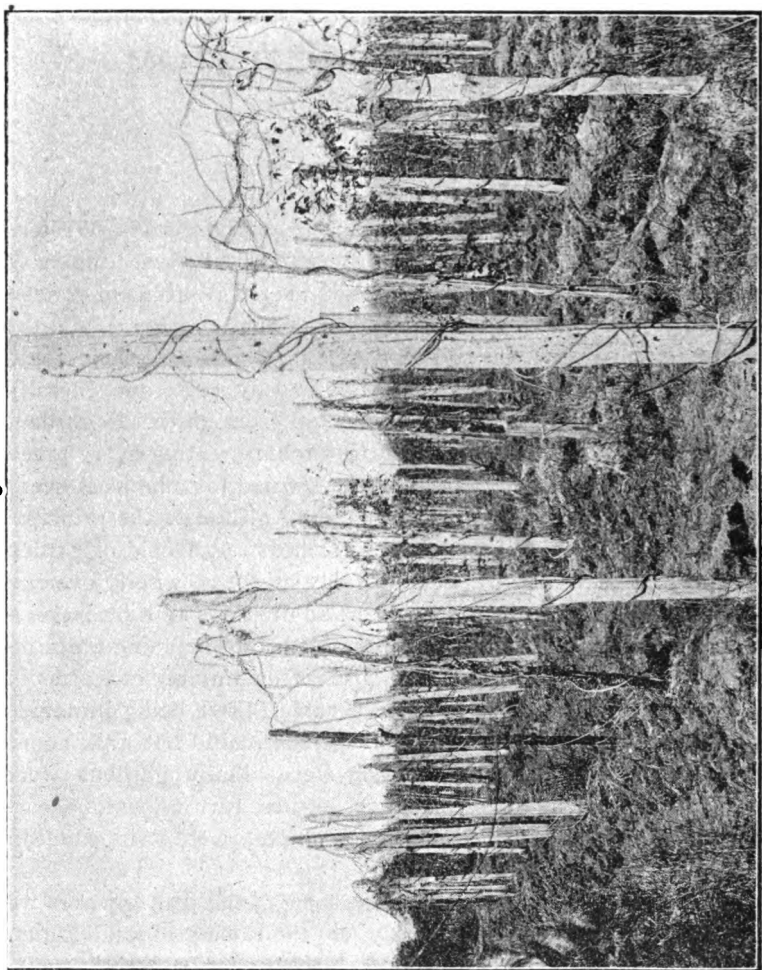


FIG. 1—Hop yard defoliated by the cutworms, August, 1900.

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having completely stripped the leaves and fruit from a tree, the greedy pest would commence on the buds and other tender parts.

Hop fields suffered severely, some plantations being completely defoliated. Whole fields of beets, corn, clover and timothy were completely ruined. Roses, sweet peas, pansies, lawns, and all kinds of ornamental trees and shrubs were destroyed. Ferns, nettles, thistles, dog-fennel, and almost all kinds of weeds had to contribute their part toward feeding the hungry horde.

Much inconvenience was caused by these worms entering houses through open doors or windows, or wherever crack or crevice large enough could be found, and many times we were appealed to for some remedy to keep these "nasty, disgusting things" or "black horrors" from the house of some woman who was "more afraid of worms than anything else on earth."

About August 1st the cutworms began to disappear very rapidly, and by the 12th or 15th few were to be found except in certain localities. But the path of their march was marked with destruction, and while it is not likely that the insect will soon again occur in such numbers, this Bulletin is issued to give those interested a better knowledge of this species, and the methods of dealing with it and other similar pests.

While this outbreak was phenomenal, it was not unprecedented in the history of the species. This insect has long been known as one of the worst of the cutworms, as it frequently occurs in considerable numbers, doing a greater or less amount of damage. Heretofore it had been comparatively rare in this state, although our collections show it to have been collected at Seattle, Yakima, Mt. Rainier, and Pullman. Most of these were taken in June or July.

HISTORY AND DISTRIBUTION.

The original home of this insect is probably Europe as it was first described from France in 1790, and is now common all over the continent. It also occurs in Asia, Africa, South America, and many islands of the sea.

The first account we have of it in the United States is by Dr. Harris, who in 1841 bred it from cutworms found in his garden, and taking it for an undescribed species called it *Agrostis inermis*,

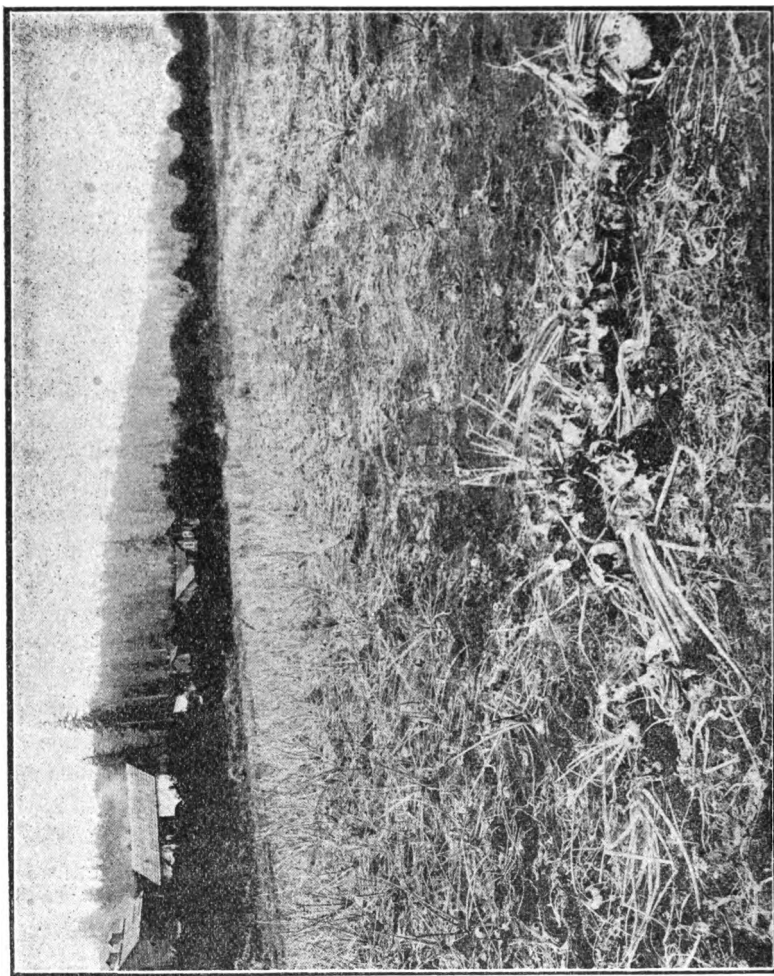


FIG. 2.—Turnip field showing the work of the cutworms. In the foreground are a few turnips showing how the worms ate out the inside.

or the "unarmed rustic." In his first annual report as entomologist for Missouri, Dr. Riley figured and described it in all its stages, gave an account of its life history so far as then known, and suggested the name "variegated cutworm" for the larva. In the 16th report of the State Entomologist of Illinois, Dr. Forbes again described the larva, and reported the taking of a full-grown larva in January, and gave additional notes on the life history and habits of the species. In the 5th report of the State Entomologist of New York, Dr. Lintner again describes the insect in all its stages, and gives valuable additional notes in regard to its life history. During the last ten years it has been frequently mentioned in various publications from the U. S. Department of Agriculture, and in several Bulletins from different Experiment Stations, the most notable among these latter being Bulletin 104 of the Cornell Experiment Station.

DESCRIPTION AND LIFE HISTORY.

The Eggs.—The eggs of this insect as described by Dr. Lintner, are round and quite small, not exceeding one-sixth of an inch in diameter. At first they are of a pink color, but just before hatching change to lavender. They are prettily marked by a number of longitudinal ridges irregularly connected by numerous transverse lines. The eggs are laid in patches of about five hundred each, on the leaves, twigs, branches or trunks of various trees or shrubs, and perhaps in other places also. The eggs laid in the spring may hatch any time between the first of April and the last of May.

The Larvae.—When first hatched the young cutworms are of a dirty yellowish or greenish color with a black head and with very distinct dark spots over the body from which arise minute hairs. They feed at first upon the delicate egg shells from which they have just emerged; later they feed upon almost any green leaves that they can find, moving about with a looping motion like the measuring-worm, and usually remaining close together. After the first moult, which takes place in about a week, they lose this looping gait, drop to the ground and assume more the habits and appearance of the full-grown worm. When full-grown they are $1\frac{1}{2}$ to 2 inches long, ashen to reddish brown above, lighter below.

A black line along each side extends the full length of the body and a less conspicuous broken black line is present on each side of the mid-dorsal line. On the next to the last segment there is a conspicuous black somewhat crown-shaped spot. There are from six to nine small yellowish or brownish spots along the mid-dorsal line and less conspicuous ones along each side. The head is darker, blackish in some specimens, and the first segment back of the head is usually dark brown. The younger specimens are much darker, usually velvety brown, the lateral lines quite con-

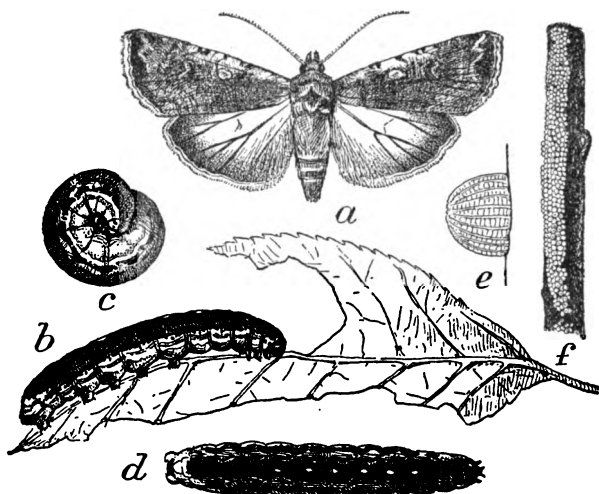


FIG. 3.—*Peridroma Saucia*.—A, adult; B, C, D, full grown larvae; E, F, eggs—All natural size except E, which is greatly enlarged. (From Yearbook U. S. Dept. Agric., 1898.)

spicuous and somewhat reddish brown, and the head reddish brown.

The Pupae.—When full grown the larvae make their way into the ground to a depth of from one to two and a half inches, where they make themselves a little earthen cell, within which they change to the pupae. These are at first of a dull yellowish color, but later become a mahogany brown. The segments diminish rapidly in size toward the anal tip which is armed with a single short, black, curved spine. The length of time that it remains in this stage varies from ten to twenty days for the spring brood.

The Adult.—The adults begin to emerge usually early in June.

The general color of the moths is reddish brown or grayish; the front wings are rather indistinctly marked with lighter gray or brown, the markings being subject to a great deal of variation. The anterior portion of the wing is frequently bordered by black or reddish brown. The hind wings are grayish or brownish above, below varying from gray to white.

NUMBER OF BROODS.

There is yet some doubt as to the number of broods of this insect that occurs during the year. Riley thought there must be at least two and possibly three broods in the latitude of St. Louis. Lintner, Forbes and others state that there are two broods in the states further north. The principal evidence in favor of there being two broods is the fact that the moths have been taken all the way from April 6 to November 6, most of them being taken, however, in June and July, and again in September and October. The length of time that it takes for the insect to complete its development is subject to a great deal of variation, the time varying according to different authors from thirty-five to sixty-five days. Previous to 1900 we had reared only one lot of these cutworms. On May 25, 1897, a number of eggs on a prune leaf was sent in by one of our correspondents. These hatched the day they arrived, and the larvae proved to be the young of this species. They feed until July 5th, when they entered the ground and pupated. The adult moths emerged August 11th, thus taking two and a half months to complete their development. In September of the same year we collected pupa under boards, stones, etc., which issued in March and April the following year. During the past season our attention was first called to the larvae on July 10th, by which time many were apparently full grown, although they were found in all stages of development from this time until as late as August 12th. The first pupa were found in the field July 20th, and by August 15th most of the larvae had pupated. The first adults emerged in our cages August 5th, the last September 18th, and we still have a number of pupae in the cages (February, 1901).

With only these dates before us, it is impossible to determine whether the insect is single or double brooded in this state. Further observations will have to be made to determine this point.

HOW THE INSECT PASSES THE WINTER.

There seems to be but little doubt but that the insect may pass the winter in the larval, pupal or adult stages. Larvae in all stages of development are found very late in the fall, and Prof. Forbes reports having found a full grown larva in mid-winter. We have carried the insect through the winter in the pupal stage.

The occurrence of the moths so late in the fall and so early in the spring would indicate that the winter may be passed as an adult. The irregularity as to the time of the appearance of the moths in the spring would also indicate that they did not all pass the winter in the same stage, some individuals appearing six or eight weeks later than others.

PARASITES.

On August 5th a number of small parasitic larvae were seen issuing from the body of a cutworm which was apparently dead. These at once spun small brownish oval cocoons from which there issued on August 12th small honey-yellow wasp-like little insects. These belong to the family *Ichneumonidae*, and through the kindness of Dr. Howard were identified for us by Mr. Ashmead as *Ichneumon maurus* Cresson. During the next two weeks many other larva were found similarly infected.

A large black wasp identified by Mr. Ashmead as *Meteorus indagator* Riley, issued from one of the pupae in the cages on August 11th.

A number of the larvae and pupa were found to contain some Dipterosus larvae, supposedly the larvae of a Tachina fly, but we did not succeed in rearing any of them. In Mr. Coquillett's "Revision of the North American Tachinidae" he gives the following as parasitic on *Peridroma saucia*: *Chaetogaedia monticola* Bigot, *Goina capitata* De. G., *Winthemia quadripustulata* Fabr. The last two are common in this state.

Early in August it was noticed that many of the larvae were being killed by what appeared to be a bacterial disease. When first attacked the worm would stop feeding and drop to the ground or fasten itself to some leaf or twig, and soon begin to turn black. In a few hours the whole body would be quite black and soft, and the larva, of course, long since dead.

While the work done by these parasites did not materially lessen the apparent number of cutworms in the field, yet their work was not inconsiderable, and it is to such agencies as these that we must look to save our crops from other serious outbreaks.

REMEDIES.

So much has been written and said about the various methods of combatting cutworms, and so many "sure cure" remedies have been found upon another trial to be of little avail that the whole subject seems to be a mass of conflicting statements. This may be explained, first, by the fact that many of the so-called "successful remedies" have been applied just at a time when the worms were disappearing anyway, and so appeared to be successful when in fact they were of no use whatever, as subsequent ex-

periments proved; second, the remedies to be used vary so much with the conditions, that no single remedy can be given that will prove equally successful at all times and places. Our energies must be directed toward fighting this insect in the larval stage for we as yet know of no successful way of combatting it in any of the other stages. It is well known that the adults are attracted to lights and trapping by differently constructed lantern traps is often resorted to, but the same amount of time and energy spent in combatting the insect in other ways would probably be of much more value. Besides this, hundreds of beneficial insects are destroyed in these traps, and quite frequently the harm done in this way overbalances the good.

METHODS OF CONTROL.

Clean Cultivation.—Experience has shown that an orchard or a garden free from weeds and rubbish is not a good breeding ground for cutworms or other insects. One of the most important items for the orchardist or gardener to observe then is clean cultivation, for not only will his premises thus become uninviting as a breeding place for noxious insects, but he will be able more easily to control any pests that do find their way to his trees or plants.

Ditching.—It is a well known fact that the onward march of the army worm can at times be stopped by digging a ditch or trench, with perpendicular walls, in the line of their march. During this last season's outbreak the variegated cutworm assumed the army-worm habit of marching in great numbers from one field to another, and was thought by many to be the true army-worm. This led some to resort to the system of ditching with very satisfactory results. If a field was still uninfested, a ditch 10 to 12 inches wide and about as deep was dug around it, or it was often found just as effective to dig the ditch only on the side from which the attack was threatened. Often a deep furrow was plowed with the perpendicular wall next the field, and served the purpose admirably. It sometimes happened that only a small portion of a field or orchard was infested at first. In many such instances the pest was kept from spreading by ditching around the infested area, thus restricting the injury to a small portion of the field, and making it much easier to combat it. The practice of digging holes at intervals of eight or ten feet along the bottom of the ditch was also resorted to, and thousands of worms were destroyed by falling in these.

Banding the Trees.—Many different schemes for preventing the worm from climbing trees were tried with more or less success. In many instances a band of tar or pitch was painted around the tree, and was effective for a short while, but it soon became dry and if a fresh coat was not applied every few days the worms soon

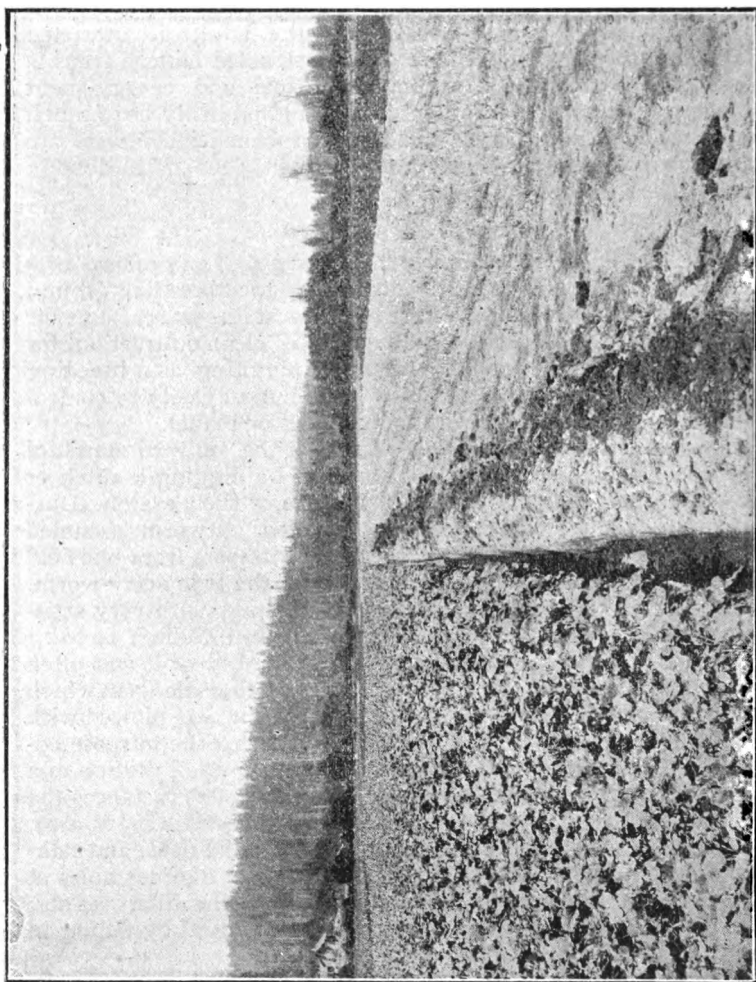


FIG. 4.—A turnip field showing the effect of ditching. The portion of the field protected by the ditch was not affected; the rest was wholly destroyed.

began crawling over it. It must be remembered also that this practice is somewhat dangerous to the trees, as many young trees have been killed in this way. In a few instances fly paper was tied around the trunk of the tree and served the purpose admirably until it became covered with dust or dirt. Strips of tin tied closely around the tree did not seem to be very effective as some worms usually got by them, either through crevices where the tin did not fit close to the tree or along the seam where the tin lapped. Cone-shaped paper collars made out of rather stiff paper was tried in many places, and where care was taken in putting these on they were very successful. The paper was tied close around the tree a short distance above the ground, with the lower edge standing out from the tree for some distance thus forming a cone. The principal difficulty comes in getting these to fit close around the tree, and in getting the edges of the paper fastened close enough where they fold over each other.

In many places in the East orchardists are using a band made of cotton batting. So successful has this plan proved that it is now used in many places to the exclusion of other methods for protecting the trees from the attacks of climbing cutworms. The original plan was simply to tie a narrow band of the cotton batting around the tree with a twine string. This acted as an effective barrier against the worms until it became wet when it seemed to lose its usefulness. To overcome this difficulty the following plan was adopted: thin sheets of the batting were cut into strips four or five inches wide, and long enough to reach around the tree. After being wrapped around the tree it is tied at the bottom instead of at the top. After the bottom is carefully tied the top of the band is rolled down over the bottom edge, and of course stands out somewhat from the tree, thus forming a sort of funnel or cone-shaped mass of cotton batting. It is claimed for these bands that they are very effective for a whole season, as they soon become dry and fluffy after being wet by a rain. Some orchardists use a band made of wool, as the rain has little or no effect on it so that it protects all the time, whatever the weather may be. With slight modification, these cotton collars could be adapted to protect hops also.

Protecting Small Plants.—Cabbages, tomatoes and similar garden plants which are very liable to be cut by the cutworms close to the ground, may often be protected by wrapping pieces of smooth, stiff paper around the stem, or by placing tin cylinders, such as fruit cans with both ends removed, around the plants.

Spraying with Bordeaux.—At Puyallup it was observed that potato vines that had been sprayed with the Bordeaux mixture for blight were entirely left alone by the cutworms, while all the un-



FIG. 5.—A potato field; the two middle rows received two applications of Bordeaux mixture and were not attacked, while the others, including those receiving only one application, are eaten to the ground.

sprayed vines in the same patch were completely eaten down. The Bordeaux was also tried on asparagus with like results. This is indeed encouraging, for if further experiments should prove that the cutworms will not attack any plant that is sprayed with the Bordeaux mixture, it will be a very easy matter to combat this pest.

Poultry in the Gardens.—During the recent outbreak it was very noticeable that in gardens and fields where chickens, turkeys and other poultry were kept the cutworms did much less damage. In fact many gardens were kept entirely free from the pest by this means. Turkeys and guinea hens seem to be particularly diligent in seeking out the larvae and pupae.

Several fields that came under our notice were visited daily by large flocks of crows, and were thus kept almost entirely free from cutworms.

Destruction of the Cutworms—Paris Green and other Arsenical Poisons.—Experiments made during the past season seem to confirm the results often obtained before while experimenting with Paris green on cutworms, namely, that as ordinarily used it is of little or no value. At least the results obtained do not seem to warrant the outlay. Used as a spray in the usual strength it was not found at all effective on hops, fruit trees, berries and many kinds of vegetables upon which we saw it tried. While many of the worms were doubtless destroyed, they were not killed quickly enough to save the trees or plants. Using the Paris green dry mixed with lime or flour met with no better success. Poisoned baits consisting of bunches of weeds, grass or clover that had been dipped in a strong Paris green mixture, met with better success, and thousands of worms were destroyed in this way.

Many experimenters have found that a poisoned bran mash has been very successful in killing cutworms. It is made by taking one part of Paris green or white arsenic to 25 or 30 parts of bran and adding enough water to form a mash sufficiently soft to be dipped out with a spoon without dripping. This is placed around in infested areas where the cutworms will easily find it. It is said that they eat it greedily, and are soon killed by it. This is a simple remedy, and well worth trying. It is especially valuable for destroying the worms in infested ground before planting cabbages, tomatoes, etc.

Hand Picking.—In many instances this good old-fashioned remedy is the very best one to resort to. It frequently happens that this is the only practical and efficient remedy. The principal objection to it is of course that it takes too much time. Last summer we saw two men at work with a spraying outfit in a small field of asparagus. They stopped at every plant and thoroughly

drenched the whole plant and every worm on it. In looking over a part of the field that they had sprayed some hours before we found the worms almost covered with the Paris green but still feeding. It required but a few minutes to demonstrate that it would take less time to shake or brush the worms from each plant and destroy them than it did to do the spraying, as they were doing it. In the one case the work was effective, in the other ineffective.

Very often the cutworms are found hidden away in numbers under boards, etc., that may be lying in the field. If such places are examined from time to time, many of the pests may easily be destroyed.

SUMMARY.

As a result of a very unusual outbreak of cutworms, the farmers, orchardists and gardeners of Western Washington suffered a very considerable loss during the summer of 1900. The worms attacked and destroyed almost all kinds of vegetation.

These cutworms proved to be the larvae of *Peridroma saucia* Hubner, an insect that is known over nearly the whole world, and has at various times done considerable damage to various crops. The eggs, larvae, pupae and adults have often been described by various authors, and much has been learned regarding the life-history of the insect, but we do not have at present sufficient data to determine whether it is single or double brooded in this state. It is probable that the insect passes the winter in any of its stages, larva, pupa or adult.

A number of parasites were found infesting the larvae. These, with a bacterial disease that was quite prevalent late in the summer very materially lessened the number of larvae.

The methods used in combatting cutworms must vary according to time, place and local conditions. No single remedy can be given that will prove equally successful at all times and places. Remedies that are very effective under ordinary conditions often become wholly useless during such an outbreak as occurred last summer. Clean cultivation will materially lessen the number of larvae that occur in an orchard under ordinary circumstances. When the worms are abundant and marching, ditching is often resorted to, usually with very satisfactory results. Banding trees is helpful under almost any conditions, in case the cutworms are climbing cutworms. It was found that plants that were sprayed with Bordeaux were not attacked by the cutworms during the recent outbreak. It is believed that this will prove to be the easiest, cheapest and most effective way of combatting this pest. Further experiments will be made along this line. Paris green and other arsenical poisons were tried in various ways, but with unsatisfactory results.

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WASHINGTON STATE AGRICULTURAL COLLEGE
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EXPERIMENT STATION,

PULLMAN, WASHINGTON.

Bulletin 48.

Department of Agriculture.

A Mechanical Ration Computer.

By W. J. Spillman, M. Sc.

1901.

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Director.

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MAR 22 '40

A MECHANICAL RATION COMPUTER.

W. J. SPILLMAN, M. SC.

Food is utilized in the body in two ways. First, it serves to keep the tissues in repair, to build new tissue, and to produce such materials as milk, wool, etc.; secondly, that part of the food which is not thus used is burned for the production of heat and energy. It is only nitrogenous substances (protein) that can be used for the first of these functions, while both nitrogenous and carbonaceous (carbohydrates and fat) substances may be burned for the production of heat and energy. But the proportion of the food burned is always much greater than that built up into tissue. it is therefore more economical to feed a large proportion of the cheaper carbohydrates and fat (fuel) than to feed exclusively on protein. There is a more important reason for feeding a large proportion of fuel rather than feeding all protein. When protein is burned in the body, one of the resultant compounds, namely, urea, must pass out of the system through the kidneys; in nearly all classes of stock, exclusive protein feeding would overtax the kidneys. Again, the digestive juices act, some on protein, and some on carbonaceous constituents of the food. Hence, in order to utilize these juices properly, it is necessary to feed protein and fuel in proper proportions. The general rule is to feed a little more protein than is actually demanded by the body, the rest of the ration being made up of fuel constituents.

The above principles are well established facts in agricultural science, and intelligent feeders generally attempt to put them in

practice, judging from the number of inquiries that come to the agricultural colleges and newspapers concerning the compounding of balanced rations, especially for dairy cows.

Dairy farmers were the first to accept the teachings of science regarding the feeding of proper rations, and for good reason. A man can compel a horse to work, whether the horse is properly fed or not, though the effort may cost the horse much suffering and greatly reduce his condition. But he can not compel a cow to give milk unless she is properly fed. Intelligent dairy-men long ago learned that it paid them to give attention to the matter of a proper balance of protein and fuel in the cow's daily food.

It is no simple matter to calculate the proportion in which two feeds, such, for instance, as alfalfa and corn, should be fed in order to give the animal a well balanced ration. And when half a dozen materials are fed daily, the problem is still more complex. Hence a large number of farmers ask advice on such questions from agricultural teachers and writers. Two of the best agricultural journals of the country make this matter of formulating rations a leading feature, and there can be no doubt that it is one of the most valuable features of these journals.

Necessity is the mother of invention. Having been frequently called upon by farmers to formulate rations, the large amount of labor thus involved led the writer some three years ago to attempt to find some mechanical means of performing the calculations necessary. After two years of study, three methods of doing so were evolved. For reasons which it is unnecessary to discuss here, two of these were discarded, and the third has now been embodied in the apparatus described in these pages. The machine is essentially double, one portion calculating the protein and the other the fuel of the ration. It is entirely feasible to construct a triple machine on exactly the same principles, the third part calculating the cost of the ration in cents per day. The whole apparatus, with the exception of the pulleys, may be constructed in a few days time by any intelligent cabinet maker, and need not cost more than \$15 or \$20. The pulleys must be accurately turned on a lathe.

It is not recommended that every farmer who desires to feed

balanced rations should possess one of these machines. It is rather intended for those who are familiar with the theory of balanced rations, and who have considerable of the work of formulating rations to do. It may seem at first glance that the machine is too complex to become generally useful. In order to test this, the writer's 9-year-old son was instructed in the use of the machine. In half an hour's time he could formulate rations with it as readily as the inventor, though he did not know the multiplication table, nor did he understand the meaning of the results he obtained. When the directions for using the machine were first written out an assistant in the department of biology, who had given no attention to the theory of balanced rations, was requested to formulate a ration from alfalfa hay and corn for fattening steers. With no assistance other than the directions and tables accompanying the machine, he had a well balanced ration in less than five minutes. The writer therefore feels that the machine may be useful to those who are interested in the matter, and describes it here for their benefit.

DESCRIPTION.

Fig. 2 shows the front elevation, and Fig. 1 the side elevation (right hand side) of the machine. These cuts are made from drawings, and are $\frac{1}{2}$ actual size. The graduations on the horizontal beam in the lower portion of Fig. 2 represent per cent, and are twelfths of an inch. The numbered notches in the rack at the right end of the beam represent pounds of food. The divisions of the right hand scale in the upper part of Fig. 2 represent pounds of fuel (carbohydrates + $2\frac{1}{4}$ times the fat). The divisions of the scale to the left of this represent pounds of protein. Index fingers attached to pulleys at the top of Fig. 2 point to these two scales. These index fingers are actuated by coiled springs, shown near the index fingers. These springs tighten cords that pass over the pulleys above and down to the graduated beams below, through a chain of pulleys as shown in Fig. 1. There are eight graduated beams like that shown in Fig. 2; they are shown in end view in Fig. 1. From each beam two cords (ordinary fish cord) pass up to the system of pulleys above, as shown in Figs. 1 and 2.

It will be seen that raising or lowering any one of the eight

beams will move both index fingers. The distance the index fingers move depends on the distance the beam is raised or lowered, and on the position of the two indicator slides on the beam.

On the frame of the machine, just above the left end of the graduated beams, is placed a table of feeding stuffs (not shown in the drawings) giving the percentage composition of all the common feeding stuffs (See Wash. State Exper. Station Bul. 43, pp. 23-25). On the right side of the frame is placed Wolff's table of feeding standards (*loc. cit.*, p. 29).

TO OPERATE THE MACHINE.

When the left indicator slide of any one of the graduated beams is set at the per cent. of protein in a food, and the right hand slide at the per cent. of fuel, that lever is said to be set for that food. Set one lever for each feeding stuff in the proposed ration. (Set two levers for such feeding stuffs as are probably needed in quantities larger than 10 lbs., except in case of succulent foods, which see below). Set the pawls on right end of all the levers in bottom, or zero, notch of the racks. Adjust the index fingers, approximately to the zero of their respective scales, by taking hold of the index fingers themselves and moving them into place. Finish the adjustment by means of the adjuster bobbins in the cords attached to the first lever. The fingers can be adjusted very accurately by this last means. (If, after using the machine several times, the adjuster bobbins appear to be wound up too much, unwind them till the pulleys immediately above them stand on a level with the other pulleys of the same size, and then adjust the index fingers approximately to zero as first directed above).

Having set the machine for the feeding stuffs in the ration, and adjusted the pawls and index fingers to zero, we are ready to calculate the ration.

Raising any beam one notch introduces into the ration one pound of the food for which that beam is set. Lowering a beam a notch takes out a pound of the material for which it is set.

The protein in the ration is indicated in pounds at all stages of the computation by the left index finger above; the fuel by the

right index finger. Add and subtract the various foods, by raising and lowering their respective levers, till the desired amounts of protein and fuel are indicated by the index fingers. The pounds of each material in the ration may then be read off by observing the numbers on the ratchet teeth immediately above each pawl.

In case of roots, and other succulent feeds, set the indicator slides at 2, 3, 4, or 5 times the per cents as given in the table of compositions; each notch on the rack will then represent 2, 3, 4 or 5 lbs. of the food, as the case may be.

For a fuller discussion of the principles of feeding, the reader is referred to Bulletin 43, of this station. It contains a very complete list of feeding stuffs, giving the percentage of digestible protein and fuel in each.

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Bulletin 49.

Department of Chemistry.

Alkali and Alkali Soils.

By W. H. Helleman, Assistant Chemist.

1901.

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DEC 10 '36

ALKALI AND ALKALI SOILS.

W. H. HEILEMAN.

Among the most fertile lands in the state are those found in the arid or semi-arid sections. In order to bring these tracts under cultivation it is necessary to overcome their arid condition by introducing adequate systems of irrigation, after which the lands thus reclaimed yield bountiful crops with minimum risks to the farmer, and also prove themselves of persistent fertility and admit of intense cultivation.

The principal cause of the fertility of these sections is due to their arid condition. We know that soils are produced from the disintegration of rocks, and that all the mineral elements of fertility are generally to be found in the rock material from which the soil is derived. We know also that during the processes of soil formation many changes take place and that certain elements are rearranged from insoluble, unavailable compounds, as found in the original rock, into compounds much more available to plants and much more easily soluble in water or water charged with carbonic acid gas.

Arid lands are those which owing to natural conditions have a very meager rainfall, and as a result the disintegrated material making up the soil body has been only partly leached of the soluble compounds formed during the weathering processes on the rock material of which the soil is composed; and hence we find these arid soils quite rich in assimilable salts of potash, phosphoric acid, and sometimes nitrate nitrogen, all three of which are very necessary to plant growth. It is not intended to convey the idea that all the soluble compounds originally produced from disintegrating rock are yet to be found in the soil of an arid region, for doubtless the greater percentage of salts formed from the weather-

ing of any rock has been leached away into the natural drainage and to the ocean long before the soil formed has been tilled. In fact, in many instances, the soils of our now arid regions are soils that have been transported by the agencies of wind and water, and have been deposited, leached of all but a small percentage of the soluble salts they once contained. As time goes on however these soils continue to disintegrate, thus increasing the amount of soluble salts either beneficial to plants or otherwise; and if the processes of leaching do not keep pace with this later disintegration the result will be that the originally leached or water-deposited soil will become clogged with salts, some of which are beneficial and others detrimental to plant growth.

In more humid regions, as for example the greater area of the Mississippi Valley, where the rainfall is comparatively heavy and where only a part of the water which falls is taken up by vegetation, conditions become quite different. In soils of such areas the soluble salts formed by the disintegration of the soil and rocks are carried away by the surplus rainfall into the creeks and rivers, and finally to the sea; or again, these salts are leached into lower levels where it becomes impossible for them to exert an influence on vegetable growth. These later conditions often show themselves as having occurred in sections where deep wells have been sunk; the water of such wells being heavily charged with salts* produced largely at the surface and carried deeply underground.

Another source of fertility in our arid Washington soils lies in the fact of their favorable mechanical or physical condition. These soils in this state are made up largely of minute particles, almost as fine as dust, and much that is capable of passing through a sieve containing sixty meshes to the inch; hence, when intelligent cultivation is practiced the seed bed presents mechanical conditions highly favorable for the permeation of plant roots into all parts of the soil in search for food.

Arid land however besides containing an abundance of plant food in the form of soluble salts essential to plant growth, contains also other soluble mineral products which exercise an *un-toward influence* on crops; and often these *harmful* soil salts

*Report VI, Iowa Geol. Survey. Artesian Wells.

through improper management or unforeseen conditions succeed in accumulating to such an extent as to destroy all fertility, and as a result what may once have been valuable, fertile land, becomes practically worthless. These harmful salts are commonly called *alkali*.

ALKALI.

Nearly all the arid land in this state contains more or less of these salts harmful to plant growth, as above mentioned. The evil effect of these salts is, however, generally noticeable only in localities where artificial water supply has hastened the accumulation of the alkali on account of inadequate drainage.

The farmer knows, generally, the effect produced by alkali on the land and the crop, especially the latter; though generally he does not understand how to discriminate between the different kinds of alkali, or to decide upon the proper means to overcome the bad results produced by the overabundance of harmful salts or "alkali."

Alkali, as the term is commonly applied in connection with soil, is a term used to indicate certain chemical compounds of a saline nature in the soil, harmful to vegetable growth. These compounds, as has been stated, are water soluble and are natural products formed during the weathering of rocks or continued disintegration of the soil-body. The common compounds or "alkalis" thus formed are not necessarily alkaline in character, nor need they belong to the class of compounds known *chemically* as alkalis; they are however compounds composed of the alkalis or alkali earth metals in combination with certain acid radicals. Their true class name from a chemical standpoint is that of *Salts*. It is not necessary to depart from the name custom has applied however, and when the term alkali is used it shall have reference to compounds in the soil of a harmful nature to plants.

The common alkalis found in our soil are sodium carbonate or "black alkali," and sodium sulfate or "white alkali." Besides these two which are generally designated as types of alkali, we often find other salts which if present to any great degree also produce serious hindrance to plant growth and are considered as alkali. Such salts as sodium chloride, or common table salt; mag-

nesium chloride; and magnesium sulfate, or epsom salts, are considered harmful and belong to the type called "white alkali."

Of the salts named, sodium carbonate or "black alkali" is the one most harmful to crops, or, it is the alkali to which crops in general can not adapt themselves readily. It is formed in the soil during the weathering processes and during the transformations and chemical changes naturally occurring in soils where the soil-water is charged with carbon di-oxide or decaying vegetable matter.

Black alkali if present even in small quantities, tends to render the soil soggy and hard of tilth. It seriously curtails the action of the soil moisture in its relations to the plant, and when very little of this salt is present in the soil at the surface, plant growth becomes almost impossible because of the corrosive effect upon the tender plant stems and the tendency of the alkali to rot the plant root, or the seed when sown. Another serious result of black alkali in the soil is shown in its ability to dissolve the humus or organic matter of the soil. This humus is often the main source for nitrogen to plants and where fields are flooded to relieve the soil of surface-alkali large quantities of dissolved humus are carried into the drainage at great expense to the soil fertility.

The corrosive effect of those salts known as *white alkali* is much less than that produced by sodium carbonate. White alkali does not dissolve humus or hinder materially the tilling properties of the soil. It tends however to rob the plant of its food supply both in preventing the plant rootlets from discriminating against the alkali, and also in its tendency to curtail the supply of moisture from the plant, and thus prevents the absorption of nutriment into the crop.

Crops can, however, withstand much more of the white than the black alkali. Prof. Hilgard, whose study of alkali problems in the West covers many years, tells us that not many plants can withstand as much as one-tenth per cent. of black alkali in the soil, while of the white alkali plants can withstand from two-tenths to five-tenths per cent.

Detection of White and Black Alkali.

There is little definite or practical knowledge among the farm-

ers for detecting whether or not the alkali salts in the soil of their farms belongs to the *white* or *black* variety. In ordinary cases the soil may be quite heavily impregnated with these salts, yet it is a matter largely of guess work with the farmer when he attempts to determine the character of the alkali. Tracts of land in alkali sections said to contain white alkali have been found upon investigation to contain little else than sodium carbonate. Presumably this was due to the fact that much of the surface alkali was crystalline in character and presented a white appearance when dry. Again, lands carrying a light colored, silicious top-soil are often mistaken for "white alkali tracts," though upon chemical analysis such soils give up practically no alkali.

It is a matter of great importance to be informed regarding the kind of alkali in a particular soil, since the treatment for its elimination depends upon its character. It is an easy matter to be misled regarding the character of alkali in the soil. Both the *black* and *white* varieties after rising to the surface present upon drying a white or crystalline incrustation. All these "alkali salts" so called are white in their pure form, and when found in the dry state one is apt to be misled by appearances.

In a general way one can detect the presence of black alkali by the brown or nearly black deposits lying close to the soil surface, and *under* the white upper incrustation or "bloom." If enough humus or organic matter is present in the soil, which is generally the case, the black alkali in coming to the surface will have brought humus with it in solution. Upon evaporation of the alkali charged water on the surface of the land, this humus shows itself as a brown crust, and this crust can be taken as satisfactory evidence that the alkali is largely of the black variety. If on moistening this surface crust the resulting liquid becomes brown or black in color it is certain evidence of the presence of sodium carbonate or black alkali. It is due to these characteristics that the term *black* alkali has been given to this salt.

White alkali when wet gives no brown color to the solution so produced because white alkali does not have the property of dissolving the soil humus. Generally however where surface soils are heavily impregnated with alkali in the sections studied, both the white and black alkalis are present, and analyses of these

heavy incrustations have shown generally that the black alkali predominates.

There are other indications for the detection of black from white alkali which the farmer may learn by observation. One of these is the tendency for the soil, in the presence of black alkali to puddle or remain soggy, and be exceedingly difficult to put into proper tilth. This is especially noticeable in soils already so inclined because of their adobe-like composition or characteristics.

The mere whitish surface appearance of a soil is not evidence of the presence of alkali. Such surfaces are presented in several sections of the localities discussed in subsequent pages. These white spots or strips in the soil are mere deposits of siliceous material much like chalk in appearance though they have no significance as alkali soils. One soon learns by leaching such surfaces that they contain little alkali, and also that they are in no sense the source of alkali as many suppose. Such soils usually lack humus.

Alkali Soils.

The presence of alkali in certain sections of this state, and the serious conditions due to alkali, which are beginning to present themselves over certain as yet small areas of our irrigated sections, has caused the chemical section of the State Experiment Station to begin an investigation of the subject. What has been done is incomplete and does not answer many of the questions naturally arising in relation to the elimination of alkali, yet the publication of results so far obtained may be of use in sections where immediate action is necessary. The present work can do little more than make a general survey of the conditions; form such general ideas as to the source of the trouble as are consistent with the results obtained, and point out important features here and there which will aid the farmer in helping himself largely in the matter of reclaiming alkali land.

Investigations have been carried on in the irrigated sections of the Kittitas and Yakima valleys. There are a few other sections of the state where alkali is more or less prevalent, though in the localities mentioned conditions are typical and results obtained give general ideas which may be applied to other alkali sections in

so far as a general study of the subject is concerned.

The two valleys mentioned contain the greater areas subject to trouble from alkali. This is largely due, of course, to the fact that these areas contain vast tracts of semi arid lands already under irrigation; and as the areas brought under irrigation in these valleys are increased there will be a corresponding increase in alkali areas *unless* past experiences succeed in teaching us how to prevent such accumulations.

The other sections of the state can perhaps never be seriously troubled with alkali because of their more adequate rainfall, their generally favorable drainage, and their limited amount of flat valley land. Of the other areas perhaps the Walla Walla district needs closest attention.

In the work in the Kittitas and Yakima valleys I have been greatly aided by many of the farmers in obtaining data, though there seemed to be a slight reluctance on the part of some to offer needed information.

The Kittitas Valley.

This valley lies a little south of the central part of the state, practically between the fourth and fifth standard parallels north, and ranges 17 to 19 East, inclusive. The general direction of the valley is north-west to south-east, the longest distance being perhaps twenty miles. The width of the valley varies, its widest portion being perhaps fifteen miles across and gradually narrowing toward its northern and southern extremities. The valley is enclosed almost entirely by basaltic and drift ridges of variable elevation and with rounded general appearance. The ridges along the sides and southern end of the valley are composed largely of basalt rock and debris, while the lower uplifts on the northern side of the valley are composed largely of gravel drift which reach far into the valley southward. Back of these deposits on the north are higher elevations composed of volcanic ash and basalt rock.

The Yakima river enters the valley at its northern extremity and flows southeast-ward through the length of the valley keeping a general position west of the center throughout the entire distance. This river is the source of water supply for irrigation in the valley.

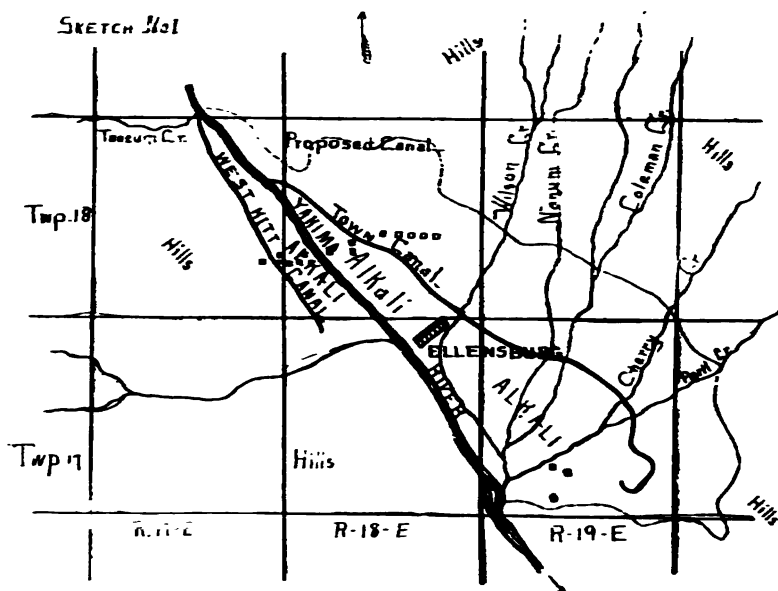


FIG. 1—The Kittitas Valley.

The irrigated section of the land lying East of the Yakima river is supplied with water from the Town irrigating canal, while the land West of the river is supplied principally by the West Kittitas canal. There are a few other ditches of private or company ownership, though in each case the supply of water is derived primarily from the Yakima river.

Emptying into the Yakima river on the East side of the valley are a number of small streams. Among these, naming from the North, are the Wilson, Nanum, Coleman, and Cherry creeks. The general direction of these streams is from North to South.

On the West side of the river, in this valley, conditions are more rugged than on the East, and fewer water courses are found, Tanzum and Monastash creeks being the principal tributaries.

The source of all these streams is in the low mountainous uplifts of the immediate surroundings, and the supply of water brought to the valley through these channels is limited. In early spring the water supply from these smaller streams is perhaps more

than adequate to the demand in those parts of the valley which they traverse, though by the time the maximum demand for water by the crops below is at hand these water courses are able to supply sufficiently only a portion of the land tributary to them.

These streams enter the valley uniformly through canyons which they have cut through solid basalt many feet thick, and it would seem to be easily possible to conserve the excessive amount of water which they carry in the early part of the season by the construction of dams at points in these streams above where they enter the valley. A much greater area of fertile valley land could in this manner be brought under irrigation or the land already supplied by these streams might thus be insured a never failing source of water supply.

These lateral streams entering the Kittitas Valley seem to maintain a rather indifferent channel when once they enter the table land of the valley, and as a result whatever sediment they carry is deposited in proximity to their entrance into the valley proper. This condition is perhaps due to the fact that the channel of the Yakima river is little lower than the beds of these streams where they enter the valley.

The relation the streams above mentioned bear to the question of alkali in the valley becomes apparent when we ask the question as to whether or not they are the source of the alkali in the valley which they enter. Only a few analyses of soil taken from localities traversed by these streams are available, yet conclusions reached by what work has been done, and also the general results obtained by a close survey of the top-soil conditions in these sections, negative the idea that these streams carry alkali from any deposited sources along their courses. The general character of the tilled land near these streams in the upper valley points toward their being rather free from alkali than otherwise, and one cannot regard these streams as a source of alkali in any other sense than that they tend, after reaching the valley, to dissolve alkali from the soil and carry it into the lower levels where it finally rises by evaporation of the soil moisture to the surface. These streams present no abnormal conditions, and do not account for the presence of the alkali soils found alike both above and below their entrance into the valley.

An analysis of the Yakima river water made at a time of year when that stream was perhaps floating its greatest annual amount of debris would also disprove any supposition that this stream carries an abnormal amount of alkali material, or in any way increases abnormally the amount of alkali found in the valley.

The following is the analysis:

	Yakima River. Grains per imperial gallon.	Columbia River. Grains per imperial gallon.	Snake River. Grains per imperial gallon.
Sand and Silica.....	4.59	.72	1.58
Calcium Oxid.....	2.45	3.20	2.08
Magnesium Oxid.....	.82	.68	.66
Ferric and Aluminum Oxid.....	3.23	.09	.12
*Potassium Oxid.....	.45	.08	.14
*Sodium Oxid.....	3.51	.36	.67
Sulfur Trioxid.....	8.59	.28	.86
Chlorine.....	Trace	Trace	.23
Organic Solids and Carbonates.....	13.65	3.41	2.37
Undetermined.....		.18	.29
	32.29	8.92	9.00

*True alkalis.

The above analysis of the Yakima river water was made from a sample taken in June at a point in the river as far south as Prosser, and during the spring freshet. We have attached to above table analyses of Columbia river and Snake river water. The three samples may be taken in a manner for comparison. The Columbia river sample was taken in August from near Pasco, Wash., with the "river about 13 feet above low water mark, and the water about average for irrigation." The Snake river sample was taken in July, with the river "three feet above low water mark," and conditions "below average" for irrigation season.

The comparison of the three samples, under the wide difference in season conditions, is hardly a just one. The low alkali content of all the samples, however, places them above suspicion, and especially is this true when a general comparison of waters used for irrigation purposes in the arid sections of the country is recalled.

Kittitas Valley Soil.

The immediate surface soil of this valley varies somewhat as to texture and origin, though taken generally the soil of the cultivated portions of the valley is composed largely of disintegrated

basalt. In some parts of the valley the basalt soil is intermixed with sand and gravel, and again other sections of the surface are covered with sandy or gravelly soils almost entirely. The floor of the valley is of sedimentary origin, as is indicated by the deposits of water-worn gravels and boulders. These deposits extend many feet in depth in the bed of the valley as has been found by prospects made for artesian water. The presence of lava or volcanic ash soil is perhaps due to the fact that much of such material was deposited during the period in which the other sedimentary deposits were being placed, and also to the fact that the present surroundings of the valley have had an influence upon the immediate surface soil of the valley.

A brief description of the different samples of soil studied will be found in the table which follows.

West of Yakima River.

The land west of the Yakima river in the southwestern part of the valley is quite sandy and full of gravel. The underdrainage in this part of the valley seems to be quite adequate, and a general survey of this section failed to show any serious indication of an excess of alkali near the surface.

Immediately north of this portion of the valley, in Twp. 18, Range 17 and 18 North, well-defined alkali strips present themselves. This may be said in general of the land under the West Kittitas Canal. The limited area under irrigation in this section eliminates the possibility of large alkali tracts, though there are two well defined strips following a slight depression in the surface, and running parallel to the river almost the entire length of this part of the valley. Samples 18 to 37, inclusive, were taken in this locality. The samples were taken across the valley from the foot hills to the river. Samples 30 to 37, inclusive, are representative of land not seriously contaminated, while the samples in the remainder of the series are taken from the alkali strips mentioned.

The problem of draining the alkali land in this part of the valley does not appear to be a serious one, and it is probable that much of the land now useless for agricultural purposes could be reclaimed at moderate expense. It is also probable that a generous supply of gypsum would reclaim a great deal of the land from

the excess of black alkali on it. A little preliminary experimenting by the farmers would no doubt give interesting results.

East of the Yakima River.

The greater part of the Kittitas Valley lying east of the river presents a generally level surface. Immediately east of the river the land seems to be quite well drained, and not seriously contaminated with alkali. The Town Irrigating Ditch, entering the valley at the north, maintains a general direction parallel to the river, though it departs gradually eastward until three miles below the town of Ellensburg the main ditch is about five miles east of the river. The general drainage for the land lying between the canal and the river is in a southwesterly direction, or *parallel* to the river.

Beginning at the north end of the valley, east of the river, and about mid way between the river and the Town Ditch, there exists a slight depression on the surface of the land. This surface depression extends the whole length of the valley, being narrow at the north and gradually broadening out as it reaches southeastward until at its southern extremity it is often as much as three miles wide. This depression throughout its entire length contains more or less alkali. In the upper part of this tract, and extending as far south as the north line of Twp. 17, R. 18, or the intersection of Wilson creek, the alkali is visibly more in streaks or small plats; but below this township line large areas are quite seriously covered with alkali, and in the localities lying near the extremity of the Town Ditch whole tracts are given up to salt grass and alkali flats.

The general character of the soil on each side of the alkali strip is of a fine, gray, ashy appearance, much like volcanic ash. The soil within the alkali strip is more or less soggy and closely knit, or sticky, though in the upper part of the valley its character is much the same as the surrounding soil. Farther below, where more alkali is present, the soil often presents a gumbo appearance, is very fine, mucky, and almost impervious to water. The heavily impregnated soils present a blue or slaty appearance.

The drainage of the irrigated land east of the river instead of

being directly to the river westward from the Town Canal, seems to be largely in a direction parallel to the river and irrigation canal until it reaches the extreme southern end of the valley, where it finally follows the drainage of the several creeks previously mentioned to the river. For this reason alkali collected by seepage water far up the valley traverses practically the entire length of the valley before it is drained into the river.

Above the Town Canal.

The land lying east of the Town Canal and extending to the eastern edge of the valley is not seriously contaminated with alkali other than in small areas where the seepage water in the earlier part of the season becomes clogged because of uneven surface cutting off the drainage. This whole area receives its moisture from the streams entering the east side of the valley, and it is in this part of the valley where is shown in a number of places, in a small way, the characteristic action of the alkali. In these small surface depressions an excess of water accumulates after flowing over or seeping through the fertile soil rich in soluble salts. The water later in the season leaves these depressions owing to evaporation, and as it passes to the surface it brings up the alkali in solution, finally leaving it in deposits where the last of the moisture leaves the soil surface.

In much the same manner, and with an unlimited amount of seepage water, the land below the Town Canal accumulates its alkali, and it is brought to the surface by evaporation. Without doubt much of the alkali found in the lower part of the valley has been brought in by seepage water from above, augmented by the alkali collected by the Town Ditch, by the system of "dead water" ditches in vogue, and by the excessive use of water in nearly all parts of the valley under irrigation.

Hard Pan.

One of the great factors which keeps the seepage water from sinking into lower levels in the soil is the presence of hard pan. Throughout the whole irrigated section of this valley, and rang-

ing from a few inches to several feet below the surface, is a well defined layer of hard pan, varying from about three inches to one foot in thickness. This hard pan consists of a calcareous layer quite impervious to water, and has much to do with permitting the soil near the surface to become clogged with alkali. Beneath the hard pan strata in many places I have found the soil supersaturated with water, the condition being such as to permit the sinking of a 2-inch auger into the soil below the hard pan by the simple pressure of the fingers upon the auger handle. The soil beneath the hard pan is generally silty or sandy, it is not inclined to contain much alkali, and it is likely true that could the moisture above the hard pan layer once find its way into the drainage deeper down, below the hard pan, little trouble from alkali would be experienced. It is a noteworthy fact that in those parts of the valley, viz: the southern extremity, most troubled with alkali, the hard pan is nearest the surface.

This calcarous, or hard pan layer, does not exist alone in the valley proper but may be found also above the irrigated sections and the lower bench lands surrounding the valley proper. Below in the valley the stratum is dark grey in color, due perhaps to organic matter and an excessive amount of soil being mixed with it. Those samples found at greater elevations were lighter in color and nearly free from organic matter.

The following partial analyses of hard pan samples from the Kittitas Valley give a general idea as to its composition. The table shows also the amount of water soluble salts (alkali) in the hard pan, and the per cent of black and white alkali. Sample No. 8 was taken in the southern portion of the valley, in Sec. 18, Twp. 17, R. 19, S. W. $\frac{1}{4}$, on the farm of Mr. Tjossem. The sample came from a depth of about three feet, the boring being made on a small divide in the field. Sample No. 21 is from hard pan stratum on the farm of Adam Stevens, at the depth of from 18 to 24 inches, Sec. 30, Twp. 18, R. 18, N. W. $\frac{1}{4}$. Sample No. 43 was taken from the valley proper at a depth of 18 to 24 inches, on the farm of Chris Eidahl. Sample No. 56, hard pan from bench land at depth of about five feet, Sec. 33, Twp. 17, R. 19, on land controlled by Mr. Frost.

	Total lime and magnesium carbonate in hard pan.		Water soluble salts in hard pan.		
	Calcium Carbonate. Per cent.	Magnesium Carbonate. Per cent.	Total Salts. Per cent.	Black Alkali. Per cent.	White Alkali. Per cent.
No. 8.....	21.15	1.72	.943	.174	.018
No. 21.....	14.93	3.09	.186	.029	.023
No. 43.....	21.79	2.97	.133	.109	.011
No. 56.....	63.22	2.45	.350	.145	.041

It is noticeable in the above table that the lime content of samples No. 8 and 43 is much the same. These samples are both from the valley proper, and are hard pan samples of the same thickness. No. 43 is taken, however, from the *north* end of the alkali strip lying on the east side of the Yakima river, while No. 8 is from the extreme *south* end of the alkali field, the distance apart being about nine miles. The water soluble salts (see table) in the two samples differ materially, however. This is to be expected since No. 8 is from the vicinity of land heavily charged with alkali which has seeped in from a very large area, while the seepage area for No. 43 is quite small in comparison.

These and subsequent analyses do not prove the hard pan to be the source of the alkali in the valley, as many suppose. In the table which is to follow it will be seen that the water-soluble material from this calcareous strata is seldom in excess of what is found in the soil overlying.

Sample No. 56 is taken from land which has never been irrigated. The question as to whether or not it belongs to the same stratum as is found in the valley proper, more investigation will be required to determine. For the present I have placed it in the same class as the other hard pan samples analyzed.

As to the origin of the hard pan in this valley, I am unable to state. The stratum, however, regardless of its origin, is nevertheless favorable to alkali accumulation in that it is quite impervious to the soil water, and prevents the alkali charged seepage from passing readily into the lower water table and away from the surface of the land. In this manner the hard pan aids in the collection of alkali near the surface and permits it to rise immediately after evaporation occurs from the surface, or as the crop draws up-

on the soil for its supply of moisture. The surface drainage of the alkali tracts rests upon this calcareous strata, and as a result much seepage water traverses nearly the whole length of the irrigated section of the valley within four feet of the surface, and the lands lying at the lower extremity of the valley, for lack of adequate drainage, become flooded with seepage heavily charged with alkali salts.

Lime Above and Below Hard Pan.

It may be of interest to insert a few analyses showing the lime content in the soil above the hard pan, and also the water soluble solids, at the different depths. The samples below were taken from two alkali tracts, the first (Boring A) on the west side of the river, and the second (Boring B) on the east side.

	Calcium Carbonate—per ct....	Magnesium Carbonate—per ct....	Water Soluble Salts—per ct....	Black Alkali—per ct....	White Alkali—per ct....
BORING A.					
No. 20—18 inches above hard pan.....	11.00	2.00	.204	.108	.018
No. 21—Hard pan (6 inches).....	14.93	3.09	.136	.029	.023
No. 22—One foot under hard pan.....	4.34	1.38	.120	.068	.025
BORING B.					
No. 41—Top 4 inches.....	5.46	1.78	.261	.210	.030
No. 42—4 inches to hard pan (18 inches).....	12.32	2.56	.175	.150	.019
No. 43—Hard Pan (6 inches).....	21.79	2.97	.133	.109	.011

The first two columns of the table show the total amounts of lime and magnesium carbonates in the soil, soluble in acid, the remaining columns show the products obtained by water extraction of the soil. We notice in each case the abundant lime content of the soil immediately above the hard pan, and the corresponding increase in each case in the hard pan proper. In "Boring A" the foot of soil just below hard pan contains very much less lime than the hard pan just above. It is interesting also to note that the hard pan contains less water soluble material (alkali) than the soil overlying. Much more work must be done along this line before any definite conclusions can be drawn regarding

the reasons *why* these conditions exist, or as to whether they repeat themselves.

The following table gives a general summary of the work done on alkali in the Kittitas valley in so far as analyses are concerned. The value of the table lies in the fact that it gives a general idea of the conditions existing in the *alkali areas* rather than that it shows any systematic details relating to the study of this important question. The results found satisfy us that a great deal more work should be done.

The samples in the table are taken generally from fields where alkali is noticeably present. The depth to which samples were taken was controlled rather by the conditions presented in each case than by a wish to maintain uniformity. The first column of figures gives the per cent of water soluble salts in the soil, and shows in general the amount of alkali present. The remainder of the table is self-explanatory:

PER CENT OF WATER SOLUBLE SALTS IN SOIL.

Number.....	LOCALITY.			DEPTH.	DESCRIPTION.	Water soluble salts in soil...	Sodium oxid... (Na ₂ O)	Sulfates..... (SO ₃)	Carbon di-oxid (CO ₂)	Black alkali..... (Na ₂ CO ₃)	White alkali .. (Na ₂ SO ₄)
	Sec.....	Twp.....	R								
1	N W ¼ 18	17	19	6-12	Hard pan	.443	.157	.196	.005	.012	.860
2	"	"	"	6-12	"	.620					
3	"	"	"	Surface crust	White crust	6.961	2.295	.060	2.125	8.840	.087
4	"	"	"	1-6	Sandy	.492	.176	.020	.205	.274	.087
5	"	"	"	6-12	Hard pan	.186					
6	"	"	"	12-18	Muck	.880	.116	.004	.088	.070	.007
7	"	"	"	18-36	Sandy silt	.280	.139	.001	.210	.229	.001
8	"	"	"	8 feet	Hard pan	.842	.119	.010	.188	.174	.018
9	"	"	"	Top inch	Salt marsh pasture	27.525	9.580	.816	12.900	16.578	.561
10	N W ¼ N W ¼ 18	17	19	Top-12	Drift partly reclaimed	.508	.186	.080	.901	.279	.053
11	"	"	"	12-24	"	.869	.129	.088	.074	.176	.049
12	"	"	"	24-36	"	.867	.127	.047	.068	.156	.083
13	S W ¼ S W ¼ 18	17	19	Top inch	Drift reclaimed	.213	.087	.019	.148	.124	.088
14	"	"	"	1-10	"	.109	.043	.004	.016	.043	.007
15	"	"	"	10-20	"	.116	.049	.010	.024	.067	.014
16	"	"	"	20-36	"	.114	.092	.009	Trace		.015
18	N W ¼ N W ¼ 30	18	18	Top inch	Volcanic	6.104	1.928	.288	2.070	2.989	.476
20	"	"	"	1-18	Volcanic to hard pan	.204	.150	.010	.045	.108	.018
21	"	"	"	18-24	Hard pan	.186	.111	.013	.012	.029	.028
22	"	"	"	24-36	Sandy	.120	.061	.014	.086	.068	.025
23	"	"	"	1-12	Volcanic ash	.144	.046	.002	.072	.077	.008
24	"	"	"	12-24	"	.288	.049	.008	.071	.084	.005
25	"	"	"	24-36	"	.040					
26	"	"	"	Top inch	Crust	9.120	6.581	.297	5.587	10.854	.527
27	"	"	"	1-24	Volcanic ash	.231	.092	.004	.115	.152	.007
29	"	"	"	24-36	Hard pan	.092					
30	"	"	"	Top-2	Basalt ridge	.070	.023	.010	.040	.027	.017
31	"	"	"	2-22	Basalt and gravel	.160					
33	"	"	"	4 feet	Hard pan	.140	.084	Trace	.104	.109	Trace

PER CENT OF WATER SOLUBLE SALTS IN SOIL.—Continued.

Number.....	LOCALITY.			DEPTH.	DESCRIPTION.	Water soluble salts in soil...	Sodium oxid... (Na ₂ O)	Sulfates..... (SO ₃)	Carbon di-oxid (CO ₂)	Black alkali..... (Na ₂ CO ₃)	White alkali.... (Na ₂ SO ₄)
	Sec.....	Top.....	R.....								
34	SE ¼ S E ¼ 25	18	17	1-12	Top of basalt hills	.082					
35	NE ¼ N E ¼ 25	"	"	1-12	Slide, basalt hills	.080					
36	NE ¼ " "	"	"	1-12	Base, basalt hills	.100	.031	Trace	.022	.053	Trace
37	" "	"	"	12-24	Basalt, below No. 36	.164	.041	.009	.029	.058	.016
38	20	18	18	Top-16	Basalt, drift	.078					
40	"	"	"	16-28	" "	.045					
41	20	18	18	Top-4	Volcanic ash	.262	.199	.017	.087	.210	.080
42	"	"	"	4-18	" "	.175	.112	.011	.105	.158	.019
43	"	"	"	18-24	Hard pan	.133	.064	.006	.088	.109	.011
44	"	"	"	Top-1	Near 41	5.588	3.184	.494	1.560	3.758	.877
45	21	"	"	Top-16	Sand and gravel	.070					
47	"	18	18	Top-16	Sand and basalt	.296	.137	.019	.140	.208	.034
49	"	"	"	16-30	" "	.096					
50	22	"	"	T-6	" "	.090					
51	23	"	"	T-4	" "	.112					
52	"	"	"	4-26	" "	.105					
54	"	"	"	26-36	Clay	.108					
55	N W ¼ N W ¼ 33	17	19	T-24	Foot hills, sandy	.108					
56	"	"	"	5 feet	Hard pan	.350	.103	.023	.245	.145	.041
57	28	17	19	T-24	Gumbo	.210	.065	.030	.035	.071	.053
58	"	"	"	T-24	" "	.880					
59	S W ¼ N W ¼ 16	17	19	T-18	Fine, ashy	.380					
60	"	"	"	18-30	" "	.180					
61	NE ¼ S W ¼ 9	17	19	T-2	" "	.508	.286	.024	.192	.447	.060
62	"	"	"	2-30	" "	.136	.048	.012	.060	.065	.023
64	SE ¼ N E ¼ 28	18	19	T-12	Sandy, basalt	.240	.111	.009	.040	.086	.016
66	"	"	"	12-24	Sandy, basalt, gravel	.064					

Samples 1 to 16 inclusive were taken in the alkali tract south of the town of Ellensburg on land owned by Mr. Tjossem. Samples 1 to 8 are from land which until the present has failed to grow crops. Samples 10 to 12 inclusive are from land that previous to four years ago was a salt marsh. This particular tract is at present being reclaimed by under drainage. The field is heavily charged with alkali though it is rapidly being reclaimed to agriculture. From an eight acre tract of this land Mr. Tjossem after three years work has been able to harvest 30 tons of timothy and clover hay. It is interesting to note the success of Mr. Tjossem's experiments. As shown by analysis the land is quite heavily charged with alkali, yet through a series of underdrains the soil water is continually leaching downward and carrying away the alkali. This prevents the alkali from rising to the surface to form incrustation and as a result a heavy timothy and clover sod is being formed where previously no growth but salt grass was in evidence.

Samples 13 to 16 inclusive were taken but a few rods distant from the above and from land forming the same tract. A few years ago this field also was a salt marsh though the present analyses show the soil to be quite free from alkali and capable of growing excellent crops. This field has been reclaimed by a series of blind ditches made by a plow invented for the purpose by Mr. Tjossem.

Sample No. 9 is taken from a field adjoining the land which is being reclaimed by Mr. Tjossem. It is of the same character as the land being reclaimed. No. 9 is taken from an 80-acre field of salt grass every part of which is covered by alkali-crust. Perhaps in no place could there be a more practical demonstration given to show a method for the elimination of alkali from land than may be seen in the three fields above mentioned.

Samples 18 to 29 inclusive were taken from an alkali tract on the farm of Mr. Stevens. This land, generally, was covered with salt grass. In a few places small plots of stone clover and timothy were growing.

Samples 30 and 31 were taken from the top of a gravel ridge or bench about 50 feet higher than the valley below though near 30 and 31. This land shows no surface alkali and grows about two tons of timothy per acre.

Samples 34 and 35 were taken from a basalt ridge lying west of the farm of Mr. Stevens. This land has never been cultivated or irrigated. It is representative basalt soil.

Samples 36 and 37 were taken from cultivated land lying below the basalt ridge above mentioned. This land was growing oats which would yield 75 bushels per acre. The land in previous year yielded 5 tons of clover per acre.

Samples 38 and 40 were taken directly east of Sec. 25, Twp. 18, R. 17, and also across the Yakima river east of the Stevens farm. This land is irrigated by the Town canal. The samples 38 and 40 were taken from land lying within one half mile of the river; this land is quite well drained and shows no surface alkali.

Samples 41 to 44 inclusive are taken directly east of No. 38 and from alkali strip lying about midway between the river and Town canal. This land is used largely for hay and is quite heavily charged with alkali. No crop was growing where above samples were taken.

Samples 45, 47 and 49 were taken above the Town canal on land receiving but little water. The soil is a mixture of gravel drift and basalt filled with boulders. This land is perhaps 50 feet higher than the valley proper. Sample No. 47 is taken from a slight depression on this gravel ridge. This depression shows surface signs of alkali. This alkali seeps in during the early part of the season from the surrounding land and during the dry part of the season is drawn to the surface by evaporation of soil moisture.

Samples 50 to 54 inclusive are taken from sage brush, drift and gravel land, which has never been irrigated or cultivated. The samples were taken directly east of No. 45 and they completed the line of holes bored across the northern part of the valley (see map). This locality (Nos. 50 to 54) shows no signs of alkali being present though the leachings show the soil to contain about one tenth per cent. of soluble salts.

Sample 55 was taken from the extreme south side of the valley, in the foot hills. The soil is sandy though much mixed with basalt soil from above. The sample is from virgin soil. The soluble salts contained are much the same as shown in No. 50, which was taken ten miles north in the drift of that part of the valley.

Samples 57 to 62 inclusive are from an alkali tract in proximity

to sample 1. The land from which these samples were taken is all quite heavily impregnated with alkali, and the soil very much like gumbo. The greater part of the tract is covered with salt grass.

Samples 64 and 66 were taken from land showing alkali, lying *above* the Town canal. This land is irrigated from water taken from Wilson creek. The sample was taken from a slight depression in the land. The surrounding land does not appear seriously infected with alkali.

General Indications.

The general results of the preliminary work done on alkali in this valley seem to show (*a*) that all the land contains some alkali; (*b*) that the land uncultivated and unirrigated shows the least amount of alkali; (*c*) that the land irrigated with a minimum amount of water as for example land contiguous to Wilson creek shows less surface alkali than the land lying under irrigating canals, and (*d*) that in all cases where an unlimited or excessive amount of water is obtainable for irrigation there are found tracts which are untirely unfit for cultivation.

The indications are, also, that the natural drainage of the land under irrigation is unfavorable for the rapid elimination of seepage water, or alkali charged water, into the river.

In nearly all borings in the irrigated section of the valley a well defined calcareous (or limestone) hardpan was found. This hardpan ranges in depth beneath the surface from a few inches to three feet. This hardpan and the layer of soil immediately overlying it hinder the drainage and prevents the alkali from being carried away from the surface and into the strata underlying the hardpan. The alkali of the valley is composed largely of sodium carbonate or black alkali.

The source of the alkali seems to be in the soil of the valley. It does not seem to rise from any deposited strata beneath the surface. In all cases the land abandoned to alkali is land which owing to its natural position must receive the drainage from large surrounding areas. This land was undoubtedly a receiving basin for alkali before irrigation was practiced in the valley though the collecting of alkali in these basins has been greatly augmented by the excess of water used in irrigation without subsequent artificial drainage.

Remedies.

It is impossible to offer, in consideration of the small amount of work done, remedies which will be adequate or satisfactory. We would urge however that farmers troubled with alkali on their land should begin investigations of their own for its elimination. On land moderately infected with alkali it is likely the application of land plaster or ground gypsum will be found of great value. The office of gypsum is to change the black alkali to white alkali; this latter being far less injurious to plant life, and it also aids the tilling properties of the soil by destroying its tendency to puddle and "bake." An acre of land experimented upon in this way will likely prove the worth of the trial and may reclaim to maximum value land which now hardly pays itself.

Those tracts of land *heavily* charged with alkali will perhaps never be valuable for cropping until properly drained and leached of their salts. It seems at the present as though the value of land would not warrant the expense entailed by "proper" drainage. The time would come however when the income from such land would well repay the expense of drainage. Work of such a nature done now would perhaps be little more than completed by the time land values had increased. True economy also urges that something of this character be begun upon since the areas yearly given to alkali naturally increase.

Experiments in drainage carried on by the Department of Agriculture in different sections of the country, and also by private parties, prove the method beneficial and the money well spent. Two methods of drainage are common; the open ditch and tile drainage. Perhaps the latter would be more convenient in farm lands even though more expensive. The ingenious method of laying wooden under-drains employed by Mr. Tjossem of the Ellensburg district might well be employed in many sections of the country. His plan, briefly stated, is a process for laying wooden tile in 3-foot joints by means of a plow so constructed as to draw into the soil after it the wooden tile attached to the heel of the plow by means of a cable. In this way about 100 yards of the drains can be laid rapidly and adequately. The cable can then be withdrawn and the operation repeated for another distance. The effect of the plow on the surface of the land is hardly to be no-

ticed, no ditch is made and the results of the work of the plow, or "mole-plow," are satisfactory. With this plow main drains and laterals are placed at required distances first determined by a series of augur holes in the ground. The entire field is drained in a scientific manner. Gates are employed to stop the flow in the drains at any season or required time. The land is flooded as needed and the dissolved alkali finally allowed to drain from the land by passing into the tiles below. No humus is lost to the soil by flooding off the surface. The object lesson shown on Mr. Tjossem's land is well worth the attention of those seriously interested. Here in one field is shown (*a*) salt marsh; (*b*) partly recovered land, and (*c*) land entirely freed from alkali in so far as cropping is concerned. Analytical results are in harmony with other appearances as may be noted by referring to the column "black alkali" in the table.

Sample No. 9 is surface salt marsh (useless).

Sample, 10, 11 and 12, partly reclaimed.

Samples 13, 14, 15 and 16, reclaimed land.

The drawing below gives a general idea of the structure of the plow. The plow is drawn by a cable and capstan.

Mr. Tjossem has lately made a plow of stronger build, and somewhat different in construction from the one here shown, though its application is like that of the cut shown below.

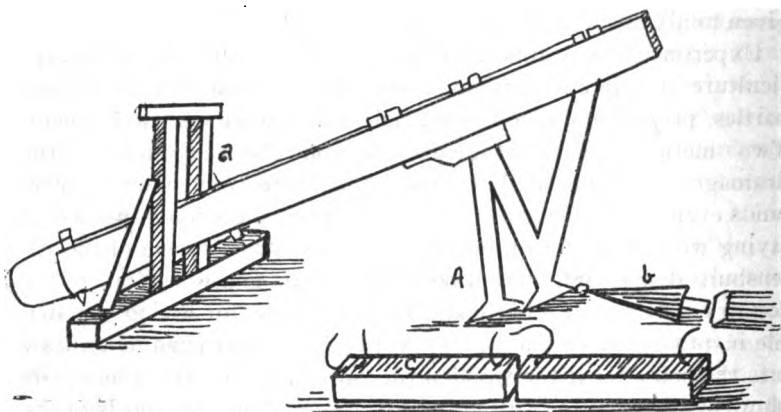


FIG. 2—"a" is plow. "b" is heel attachment which runs a "mole" the shape and size of the wooden tiles; "c" is a section of wooden tile. Instead of wiring as here shown Mr. Tjossem now uses a cable which can be withdrawn after the drain is laid.

Another method of draining land is by the use of blind ditches. This method has proven successful generally where applied. The above plow could be used for this purpose, though the insertion of tile drains is better.

In many instances the land is temporarily relieved of its surface alkali by surface flooding and finally carrying the salt away in surface drains. In the case where black alkali predominates this is a very expensive method of procedure since the humus lost by being dissolved in the alkali solution cannot again be replaced without much careful treatment. In soils so fertile as those of this valley such precaution seems perhaps a little ill-timed, and yet analyses made here on several samples of flooded surface-soil of this valley showed it to be almost devoid of humus. In each case lands where these samples were taken had been treated for alkali by flooding.

In conclusion I wish to say that the alkali question in sections of this valley is a serious one, and while the methods for its elimination do not appear to be difficult or insurmountable, the condition is such nevertheless that further delay increases the difficulty many fold.

The Yakima Valley.

The Yakima valley and its tributary divisions represents perhaps the largest irrigated section of country in the state. This section in a general way may be said to occupy a position on each side of the "third standard parallel north," in range 17, 18, 19 and 20. Its most northern boundary is in the neighborhood of the north line of Twps. 14, while its southern extensions reach south-eastward along the Yakima river almost to the junction of the Columbia and Snake rivers.

A general description of the Yakima valley, its soils, irrigation canals, artesian wells, etc., may be found in Bulletin 31, of this station, and hence will not be repeated here.

Alkali.

Only a limited time was spent in the study of the conditions in this valley and the area covered is correspondingly limited. A general survey of the valleys lying north of the junction of the

Natchez and Yakima rivers did not disclose any alkali tracts of serious nature. The remainder of the time given to this locality was spent principally in the Moxee and Ahtanum valleys, including a trip into the Sunnyside district and across the Yakima Indian reservation into the neighborhood of Ft. Simcoe and into the Cascade foothills. The principal parts of this valley infected more or less with alkali are to be found in the lower Ahtanum valley and the lower Moxee.

The Moxee Valley.

The principal parts of this valley troubled with alkali are to be found under the Hubbard ditch and toward its southern extremity. The soil of this section is largely basaltic. In the lowest levels it is of a very fine texture, of a light ashy color, and has a tendency to puddle easily. The drainage of this valley follows the general line of the irrigating canal to its southern extremity. At this place the surface breaks into a large slough lying in proximity to the Yakima river where it passes through the gap below the Yakima valley proper. Between this slough and the ditch which supplies water for irrigation there is a well defined alkali flat.

By referring to the sketch map further on, and noting the areas sampled, an idea will be obtained as to the locations.

The principal cause for an excess of alkali in this section is perhaps due to lack of proper draining. The natural dip of the surface, the depositing of alkali from dead or waste ditches, and the excess of water used in irrigation, have caused this lower part of the valley soil to become charged with alkali.

In only one case, (potato patch on Moxee ranch), was a hardpan encountered, and tests made upon this hardpan did not indicate that it was of a specially menacing character.

The character of the surface alkali in the plots most infected is sodium carbonate or black. This does not hold as a general statement however because the greater part of the alkali land in this section contains an excess of white alkali.

The following table of analyses of water soluble material in samples from the Moxee valley is self explanatory:

[illegible]

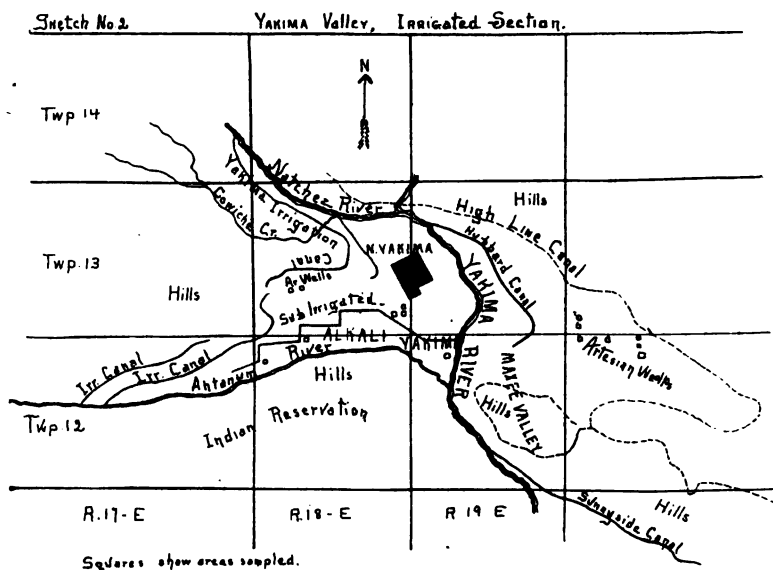


FIG. 3—The Yakima Valley.

Nos. 68 and 67 were taken in potato field on the Moxee Ranch. The samples came from near a waste ditch running through this field. While the per cent of black alkali is high, it will also be seen that the white alkali is much in excess of what was found in the Kittitas Valley. The presence of sodium chloride or common salt is also noticed. This land, away from the waste ditch, yields very well.

Samples 69 and 70 were taken from the Moxee "cattle ranch." The field is a salt grass plat and has never been cultivated. This tract receives seepage water from a wide area lying above. It is directly in line of the drainage below the extremity of the Hubbard canal.

Samples 71, 72, and 74 are taken below the extreme end of the Hubbard canal from originally greese-wood land, now sown to alfalfa. The land has been cultivated two years. It lies immediately north of basalt foot hills. The land is of adobe character, and very closely knit. Small lateral irrigation rills flood their

water over this land for days without moistening the soil more than three inches in the bottom of the rills. It is interesting to note that the strata here, below 30 inches, is characteristic basalt soil, loose in texture, brown in color, and entirely unlike the adobe top-soil. Nearly all the alkali in this field is sodium sulfate. Common salt is also present. (See table.)

Sample 76 was taken to 18 inch depth in the Bell hop yard. No alkali showed on the surface here, and the crop was bountiful. This is a very old field; it was once planted to tobacco. The soil to three feet depth is all the same in character.

Samples No. 80 and 81 are from sage brush land, never irrigated or cultivated. Soil is a fine basalt or volcanic ash.

Sample 82 was taken from south end of Hiscock hop yard. No alkali was shown on the surface. Land has been cropped a number of years.

Sample 83 is from north end of Hiscock hop-yard. This is an 80 acre field of hops. No alkali was noticed on the surface.

Samples 99 and 100 were taken from the upper end of the Moxee valley, in the artesian well locality, from virgin greasewood land. The soil is brown in color, and of basalt origin.

Remarks.

Results obtained from the work done tend to show that the alkali in this valley contains much sodium sulfate and sodium chloride; both salts being of the *white alkali* type. In those parts *heavily charged* with alkali a great amount of sodium *carbonate* is present, though this is only the case, so far as studied, upon land long given up to alkali and salt marsh.

Perhaps the most satisfactory method to employ on this land for the elimination of alkali is underdrainage. In places where black alkali exists on cultivated land, a treatment of gypsum would doubtless be of much value.

The soil of this section is not specially well supplied with humus, and any method employed which entails flooding the land to eliminate the alkali should be discontinued.

The Ahtanum Valley.

This valley is tributary to the Yakima valley proper, in fact it

forms a part of it. The Ahtanum valley extends almost directly westward from the old town of Yakima. Its principal stream is the Ahtanum River. The land lying in this valley is irrigated with water from the Ahtanum and Natchez Rivers.

The soil of this valley is much like that found throughout the whole Yakima basin. The immediate surface of the valley is covered largely with basalt soil, though much of this is underlaid with gravel and drift of previous deposition.

Alkali.

The Ahtanum Valley contains the largest tract of land given to alkali in the irrigated section of the Yakima Valley. This is perhaps due to the fact that the lower end of this valley is receiving seepage water from lands in the valley longest under irrigation. It is also true that the alkali tract of the Ahtanum is in the line of drainage from the whole western part of the valley. The alkali tract begins at the Yakima River near the mouth of the Ahtanum (see sketch) and extends up the valley along the Ahtanum River for a distance of over ten miles. The width of the tract varies, being perhaps two miles on its eastern side, and gradually narrowing as we proceed up the valley.

Nearly the whole of this tract presents during the dryer season of the year a white surface appearance, due to the salts having collected on the surface by evaporation of the soil water. Much evidence is also given for the presence of black alkali because of the great amount of brown incrustation near the surface, and the brown color given to the seepage water where it collects in the surface depressions.

Not many years ago much of this salt flat yielded bountiful harvest; and yearly the area of this alkali field is increasing in size through its encroachment upon land at present capable of growing crops.

The lands longest given to alkali are at present covered with salt grass; other sections are practically barren of vegetation, and yet another portion is virgin with its growth of sage brush free from grease-wood—the black sage brush being perhaps present before the alkali began accumulating.

Immediately north of the Ahtanum alkali, and taking in a part

of a section of country known as Wide Hollow, is a tract of sub-irrigated land. For some time it has been unnecessary to surface irrigate this land because of the moisture which comes up from below being adequate for crop production. This land is underlaid at the depth of about three feet with a stratum of gravel. This gravel serves as a channel for water which seeps in from above, and since this water does not readily find exit into the river bed below, it naturally rises toward the surface and is employed as a supply for crops.

Doubtless the moisture underlying the sub-irrigated district is annually bringing to the surface a portion of the alkali it has taken into solution from the soil through which it has percolated. This is shown by the fact that throughout the lower levels of the sub-irrigated localities alkali spots are continually appearing on the surface and yearly growing in dimension.

The same causes that have been previously mentioned for other localities apply here perhaps as adequately. It is simply a question wherein unforeseen circumstances and neglect have introduced serious problems. An unlimited supply of water has been spread over a large scope of land rich in plant food and salts left in the soil through natural agencies. No allowance has been made for the elimination of the excess of seepage water, and the fact that water dissolves the soluble salts of the soil and carries them into the lower levels of the valley surface, at all times, has not been sufficiently understood. As a result of this, great quantities of soluble salt material have been collected from the soil over wide areas and deposited in narrow localities, as determined by natural, physical laws.

The importance and gravity of the situation would indicate that something should be done to check these untoward influences which threaten to become more wide-spread in the near future. It would seem as though some adequate system of drainage for these, as yet, limited alkali areas could be introduced; some system which, while it might not overcome what now exists, would at least tend to prevent further trouble.

The following table shows the water soluble material (salts) and alkalis found in representative samples of soil from the alkali sections of the Ahtanum Valley, also a few samples taken from the sub-irrigated district:

AHTANUM VALLEY ALKALI SOIL.

Number.....	LOCALITY..			DEPTH.	DESCRIPTION.	Water soluble salts in soil...	Sodium oxid... (Na ₂ O)	Sulfates..... (SO ₃)	Carbon di-oxid (CO ₂)	Black alkali.... (Na ₂ CO ₃)	White alkali ... (Na ₂ SO ₄)
	Sec.....	Twp.....	R								
84	SW ¼ NW ¼ 5	12	18	Top-4	Basalt	1.860	.968	.048	1.020	1.586	.062
85	" " "	"	"	4-28	"	.340	.148	.041	.180	.191	.070
87	" " "	"	"	Top-4	"	.508	.251	.063	.143	.345	.112
89	" " "	"	"	4-16	"	.460				.230	.210
90	" " "	"	"	16-28	"	.240				.101	.116

THE SUB-IRRIGATED SECTION AHTANUM VALLEY.

91	NW ¼ 36	13	18	Top-4	Basalt	.660				.100	.420
92	" " "	"	"	4-12	"	.060				Trace	.040
93	" " "	"	"	12-24	"	.059				"	.050
94	" " "	"	"	24-36	Gravel	.283	.071	.042	.031	.070	.075
95	" " "	"	"	24-36	"	.122	.061	.086	.028	.056	.061
96	" " "	"	"	Top-6	Basalt	.965	.167	.279	Trace	Trace	.889
97	" " "	"	"	6-18	"	.440					.860
98	" " "	"	"	Top-12	Basalt [barren]	.520	.225	.285	.003	.007	.505

SOIL FROM PARKER BOTTOM, SUNNYSIDE DISTRICT.

103				Top-12	Volcanic ash	.080					
104				12-24	"	.090					
106				24-36	"	.080					
102				4 feet	Silicious strata	.045					

GENERAL REMARKS.

The results of the work done in the Kittitas Valley indicates that the alkali soils of that valley are quite heavily charged with carbonates, and that sulfates and chlorides are present only in limited amounts. Soluble salts of lime and magnesia are also quite absent, though the carbonates of these salts are plentifully distributed throughout the valley.

The alkali areas in every case have been brought into existence through the action of the soil water on the soluble salts naturally existing in the soil and distributed generally throughout all parts of it; and the position of these areas has been determined by the natural drainage of the land previous to the advent of irrigation, and also largely since irrigation has been introduced.

Lands, generally, in proximity to alkali tracts show a high alkali content—often near the limit for crop production. This and other facts learned during the investigation show that the alkali areas are steadily increasing in size.

The alkali soils of the Yakima Valley contain both sodium carbonate and sulfate, and often also sodium chloride. The heavily infected soils show the most sodium carbonate, while in other areas the sulfate is to be found in excess. The *greater* part of the alkali of the Yakima Valley is sodium sulfate. The soil does not show a high per cent of lime or magnesium carbonates. Other general conditions for this valley are the same as those noted in the Kittitas.

Suggestions made relative to the use of gypsum on the black alkali, and the introduction of adequate drainage to keep the salts in the soil steadily moving toward water courses, might be acted upon at least in a small way by the farmers of these sections. The results of such work or experimentation would doubtless return adequate value for the labor and money expended. Alkali land grown to salt grass has perhaps a value of ten dollars per acre, while the same land reclaimed has nearly five times such value. The favorable climate and other surroundings bespeak a steady growth in land values for these sections, and conditions at present would merit an exertion on the part of the land owners toward the protection and reclamation of the land from alkali.

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WASHINGTON STATE AGRICULTURAL COLLEGE
AND
SCHOOL OF SCIENCE

EXPERIMENT STATION

PULLMAN, WASHINGTON

Bulletin 50

Department of Veterinary Science

A Preliminary Report on Glanders

By Sofus B. Nelson

1902

All bulletins of this station sent free to citizens of the state on application to the
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A PRELIMINARY REPORT ON GLANDERS.

SOFUS B. NELSON.

Study of Mallein Test Records.

Since the Russian veterinary surgeon, Kalning, in 1891, began the preparation of mallein, and to experiment with it as a diagnostic agent in equine glanders, the veterinary profession in general has accepted it as the most satisfactory agent in glanders, especially in those instances where the possibility of a doubt as to a correct diagnosis being established through physical examination of the patient might exist, no matter how carefully such examination might be performed. When mallein was first introduced, it had to overcome the prejudice of certain individuals, including both veterinarian and layman, who would not accept against their own judgment the contrary results, as might occur from the injection of a small quantity of mallein under the skin of the patient; they reasoned, for instance, When the symptoms were not specific, how could the use of mallein reveal that glanders was present. The above antagonism was increased during the earlier years of the mallein test by the errors resulting from the misuse of and careless technique in making the injection, and therefore the naturally resulting misinterpretation of its action. This, of course, was not to be wondered at, since the mallein was used by persons unacquainted with the test; nevertheless, against all of these difficulties, mallein has in the last ten years proven itself in the hands of competent and careful workers a very valuable diagnostic agent. It was, therefore, with great interest that, six years ago, this Experiment Station began the use of mallein as an aid in diagnosis of glanders. Since then, several hundred horses have been tested, and out of this number have been selected the record of seventy-six cases to illustrate the results obtained from its use. In the following tables the black-face figures indicate reactions to the test:

No. of animal	Sex.	Amount Injected.	Time of Injection.	TEMPERATURES BEFORE INJECTION.												
				8 A.M.	10 A.M.	12 M.	2 P.M.	4 P.M.	5 P.M.	6 P.M.	7 P.M.	8 P.M.	9 P.M.	11 P.M.	1 A.M.	5 A.M.
1	gelding	1 c c	10.00 p.m.		100.2	100.8	100.6	101		101.6		101				
2	"	1	9.45 p.m.			101.8	102.2	102.8				102				
3	mare	1	12.00 "	100.5	100.5	100.8	101.1	101.2		101.8		101.2				
4	gelding	1	7.00 a.m.		101			100.8				101				
5	"	1	"		100.8			100.8				100.6				
6	"	1	"		100.8			101				101.6				
7	"	1	"		100.6			101				100.8				
8	"	1	"		101			101				100.8				
9	"	1	"		100			100				100.8				
10	"	1	"		100			100.6				101.6				
11	"	1	"		100			100.4				100.8				
12	"	1	9.15 a.m.			99.8				100						
13	"	1	9.00 a.m.							100.8		100				
14	"	1	"							101.6		101.4				
15	mare	1	"							101.4		101.4				
16	"	1	"							101.2		101.4				
17	gelding	1	8.00 a.m.		102.2	102.2	101	101								
18	"	1	12.00 p.m.	100	100.4	100.4	99.8	98.4		100		99.4				
19	"	1	5.00 a.m.						101.4		101		100.5	99.8	99.8	99.5
20	"	1	"						101.6		101.1		101.5	101	101.4	100.8
21	"	1	8.00 a.m.	102			101.3			101.2						
22	mare	1	"			100.6				101.2						
23	gelding	1	"			100.6				101.2						
24	mare	1	10.00 p.m.	101	101.2	101.2	101.8	103		102.2		101				
25	"	1	"	102.2	100.6	100.4	99.9	101.8		100		100.2				
26	"	1	6.00 a.m.	98.2			98.4	68.6								
27	gelding	1	8.00 a.m.		101.4		102.4	101.8								
28	"	1	"		99.2		101.2	101.2								
29	"	1	9.00 a.m.					100.1		100.2						
30	mare	1	"					101.2								
31	mule	2	7.00 a.m.					101.2		101						
32	mare	2	"													
33	"	2	"													
34	"	2	"													
35	gelding	2	"													
36	mare	2	"													
37	gelding	2	"													
38	m. mule	2	"											101.3		
39	mare	2	"													
40	"	1	6.00 a.m.	101		100		100.4								
41	"	1	"	101.6		101		101								
42	"	1	"	100.4		100.4		101								
43	"	1	"	100.4		100		101								
44	gelding	1	12.00 p.m.	99.4			99.6					100				
45	"	1	"	99.4			99					90				
46	"	1	"	99			99.6					99				
47	"	1	"	99.4			100					100				
48	"	1	"	100			102.4					100.6				
49	mare	1	6.00 a.m.	100.8		100.8		102.2								
50	"	1	12.00 p.m.	100.4			102					101.4				
51	"	1	6.00 a.m.	101		99.8		100								
52	"	1	12.00 p.m.	99.8			102					100.2				
53	gelding	1	"		101.8			101.8				100.8				
54	"	1	"		100.8			100.2				101				
55	"	1	"		102.4			101.6				101				
56	"	1	"		101			100.8				100				
57	"	1	7.00 a.m.		100			100.4				101				
58	"	1	"		99.8			100.2								
59	mare	1	12.00 p.m.		101.6			100				100				
60	"	1	"		100.6			100.6				101				
61	gelding	1	"		101.4			99.2				68.8				
62	"	1	"		101			99.2				100.6				
63	"	1	"		101.6			100.2				100.4				
64	mare	1	"		101.6			100.4				101.2				
65	gelding	1	"		102.6			100.6				101				
66	"	1	"		101			100.4				100.4				
67	"	1	"		99.4		3	99				99.4				
68	mare	1	"		100.2		P.M.	100.8				101				
69	gelding	1	8.00 a.m.	99.5			99.7					100.3				
70	"	1	"		100		99.8					99.7				
71	mare	1	"		100.6		100.8					100.6				
72	gelding	1	"		101.4		101.9					101.4				
73	"	1	"		100.2		100.4	100.5				100				
74	"	1	12.00 p.m.	102.6			102.4					101.2				
75	"	1	"		99			100				100				
76	"	1	"		100			100.2				100.2				

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Bulletin No. 50—A Preliminary Report on Glanders

5

TEMPERATURES AFTER INJECTION.

No. of animal	6 A.M.	7 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	12 M.	1 P.M.	2 P.M.	3 P.M.	4 P.M.	5 P.M.	6 P.M.	7 P.M.	8 P.M.	9 P.M.	10 P.M.	12 M
1	100.7	100		99.4		100		101		102		100.8						
2	102.1	102.2		103		103.0		103.5		104								
3																		
4			100.6		99.8		100.8		101.2		101.2		101.2					
5				100.8		101		100.8		102		101.6						
6				100.5		101		100		100.8		101.2		102				
7				100.8		101.2		104.8		105		105.8		105.4			101.6	100.6
8				100		100.8		103.8		104.8		105.2		105.2			102.2	102.2
9				100.8		101.4		105		105.6		105.8		104.8			104.8	105.8
10				100.4		101.4		104.6		105.2		105.5		105			105.6	105.8
11				101.4		101.4		104		105.8		105.8		105.6			105.8	105.8
12				100.8		103.5		103.5		105.2		106		105.4			105.8	104.6
13				100		100		100.2		100.2		100.4		101.2			100.8	105
14			100			99.6		99.8		100.4		100			100.8			101.8
15			101.6			101.4		101.2		101		100.2			102			101.8
16			101.2			99.6		100.6		101.2		100.8			101.4			101
17	2 A.M.	4 A.M.	101.4			99.8		100.2		101.4		101.4			101.8			101.4
18	99	99.8	101.8		100.6	103	101	101.2		101.6		101.6		101.6		101.2	101	
19		99.8			103	104.2		102.8		103.4		104.6		104.4				
20		101.4			101	101.9		104.5		104.8		105.5		105				
21		6 A.M.	100		101		101.2		104		104.6		104.3					
22		100.2			100.4				102.4		104.6		105.2		105.2			
23	6 A.M.	100.2			100.2				103.1		105.2		106.1		105.3			
24	103.4				103.8		103		102.6		102.6		102.6		106			
25	101				100.4		100.2		102.2		101.2							
26	98.4				98.5		98.6		99					99.5				
27	101.2				101.2				101.9					103.4			104.8	104.8
28	99				100.1				103.9					103.6			104.8	104.4
29					100									104.4			104.4	104.4
30					101.4									104.3				
31	101.2				101									102.3				
32	101				101.1									102				
33	101				101.1									101.4				
34	101				101.1									102				
35	101.1				101									102				
36	101				101.3									102				
37	101				101.1									102.1				
38	101.2				101.4									102				
39	101				101									102.5				
40	99.6				99.8									102				
41	101				102													
42	99.8				100.2													
43	98.4				100.2													
44																		
45	102.6				104.4													
46	99.6				104.4													
47	99				104.8													
48	100.2				102.6													
49	102				102.8													
50	100.8				100.4													
51	104.4				100.4													
52	182.4				100.6													
53	100.8				103.2													
54	99.8				102.8													
55	100				100.6													
56	100.8				102.8													
57	101				99.8													
58	101				102													
59	101				100.4													
60	99.4				103.8													
61	99.8				99.8													
62	99.8				99.2													
63	99.6				101.2													
64	100.4				101													
65	100.4				100.2													
66	100				100.4													
67	98.4				101													
68	99				99.2													
69					101													
70					103.8													
71					99.9													
72					100.1													
73					100.7													
74					100.8													
75	102.2				99.8													
76	100				100.2													
77					104.2													
78					104.4													
79					104.4													
80					104.4													
81					104.4													
82					104.4													
83					104.4													
84					104.4													
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109					104.4													
110					104.4													
111					104.4													
112					104.4													
113					104.4													
114					104.4													
115					104.4													
116					104.4													
117					104.4													
118					104.4													
119					104.4													
120					104.4													
121					104.4	</												

No. of animal	Temperatures the day following Injection.					
	1 a.m.	6 a.m.	8 a.m.	9 a.m.	12 m.	3 p.m.
4	100				102.2	101.8
5	102				100	100
6	103.5				103.5	103
7	103.8				104	104
8	104				103.4	103.8
9	105				105.8	104.8
10	104				103	102.4
11	105				104.8	104.8
31		101	101			
32		101	101			
33		101	101.1			
34		101	101.2			
35		101	101.2			
36		102	102			
37		101	101			
38		103	103.1			
39		101.2	101.2			

In summarizing the reports of these tests, this data is obtained. Of the seventy-six animals tested, thirty-six re-acted, while forty did not re-act to the injection; in thirty-three were present external symptoms, such as catarrhal nasal discharges, chronic cough, indurated and enlarged submaxillary glands, subcutaneous abscesses or farcy buds. Out of these, Nos. 1, 25, 36, 37, 39, 49, 51 and 73 either gave no re-action or an indecisive one. They presented the following symptoms:

No. 1.—Profuse, purulent, unilateral nasal discharge, no visible nasal ulcers, submaxillary glands quite swollen.

No. 25.—A limited amount of yellowish catarrhal secretion was discharged from the right nostril, submaxillary glands swollen, but no ulcers in nostrils.

No. 36.—No chronic cough, no nasal discharge, mastitis, submaxillary glands swollen, small eruptions over the left eye.

No. 37.—Coughs frequently, slight purulent discharge from both nostrils, glands swollen, nasal ulcers absent.

39.—Cough and quite heavy purulent discharge from both nostrils present, glands not swollen.

No. 49.—Bilateral nasal discharge, ulcers present in nostrils, glands severely indurated.

No. 51.—Chronic nasal discharge from both nostrils, nasal

membrane covered with characteristic ulcers, submaxillary glands swollen.

No. 73.—This animal had an offensive, purulent, bilateral, nasal discharge, coughs frequently, no ulcers visible in nostrils, glands were normal.

Nos. 1, 25 and 73 were individual animals, and in each case the history given by the owners was that the animal had previously suffered from an attack of influenza, and that since such illness the catarrhal symptoms had existed. There seems to be no reason to doubt such histories given by the owners, as they personally requested the mallein test should be given, in order that they might act intelligently relative to protecting the rest of their horses.

No. 1 yielded rapidly to treatment for catarrh.

For No. 25, treatment was not desired by the owner, and eight months later he was lost to observation.

No. 73 is at the present time under treatment and observation, there is much improvement in his condition and he bids fair to recover.

Nos. 36, 37 and 39 belonged to a band of eight that were tested, and only one gave a distinct re-action. These animals were all quarantined; and when they were examined some weeks later, Nos. 36 and 37 had recovered. No. 39 was then placed under treatment. Two months after this, he was again examined and pronounced well. This was an instance of glanders and influenza existing in the same band, and consequently made this outbreak a rather difficult one to handle.

No. 38 of this band re-acted and was destroyed. Pathological lesions of glanders were present, such as ulceration of the nasal mucous membrane and the indurated lymphatic glands. The bacillus mallei was obtained and isolated and stained in the laboratory, giving conclusive evidence of the disease.

The case of Nos. 49 and 51 is of considerable interest, as one week after the first injection, to which they did not re-act, they were retested and gave a typical re-action. When they were destroyed, eight weeks later, post mortem examination of No. 49 revealed characteristic ulcers in the nostrils, farcy buds had appeared on various parts of the body, the lungs as well as the other

internal organs gave no evidence of pathological lesions. At the same time, No. 51 was destroyed, and the mucous membrane of the nostrils, septum and turbinated bones was covered with ulcers, and the lungs contained many glander nodules. The author is unable to give any plausible reason for these two animals not reacting to the first injection. It is true that through an error their temperatures were noted only for ten hours after the injection was made, but at the second test, seven hours after the injection of the mallein, Nos. 49 and 50 had temperature of 104.4 and in 51 and 52 it was 102.4. The mallein was comparatively fresh in both tests.

In the case of the twenty-five animals showing symptoms of glanders and giving typical re-action to the injection of mallein, thirteen were autopsied. The ante mortem symptoms and post mortem lesions were observed and noted.

No. 2.—Symptoms : A sticky, glairy, mediumly plentiful nasal discharge from both nostrils, typical ulcers covering the mucous nasal membrane, the submaxillary lymph glands swollen.

Autopsy : Ulcers extending over the membrane of the nose septum and turbinated bones, a few ulcers in the larynx, the lung contained scattered nodules containing a creamy pus.

No. 22.—Symptoms : Chronic cough, nasal discharge and hemorrhage from the left nostril, glands of submaxillary regions slightly swollen, no nasal ulcers visible.

Lesions : In the superior part of the nostrils were characteristic ulcers, these extended even to the larynx, lungs showed congested patches, but no nodules.

No. 23.—Discharge from left nostril, submaxillary glands swollen.

Lesions : Mucous membrane high in the nostrils pitted with characteristic ulcers, lungs normal.

Why did this animal not show discharge from both nostrils? Was it because he had only been affected five weeks?

No. 24.—Symptoms : Nasal discharge from both nostrils, submaxillary glands enlarged, ulcers visible on the lower portion of the nasal septum.

Lesions ; Left surface of the septum nearly completely covered with ulcers, on the right side only five ulcers, mucous membrane

of left turbinated bone ulcerated, lungs normal. Microscopical examination gave positive evidence of the disease.

No. 27.—Symptoms: There were a few scattered ulcers on the schneiderian membrane, the submaxillary glands were slightly swollen, a slight watery discharge was observed from both nostrils. Eleven days after the mallein injection and just prior to his destruction, he developed a quite severe attack of farcy. From the ulcers the bacillus mallei was demonstrated to be present.

No. 28.—Symptoms: Muco-purulent discharge from the left nostril, a watery discharge from the right one, induration of the submaxillary glands, small ulcers in both nostrils. After the injection the discharge from the nostrils increased perceptibly.

No. 38.—Symptoms: Chronic cough, purulent hemorrhagic discharge from both nostrils, dyspnoea, sores visible on the nasal mucous membrane, lymphatic glands enlarged and hardened.

Lesions: Nasal septum thickened and covered with ulcers, liver somewhat degenerated. Microscopical examination of pathological specimens revealed the specific bacterium.

No. 41.—Symptoms: Bilateral nasal discharge, ulcers visible in left nostril.

Lesions: Nasal mucous membrane of left nostril covered with ulcers, a few scattered ones on the right side, there is nearly perforation of the septum, the lungs contain a large number of nodules varying in size from a millet seed to that of a pea, they are pearly white in color and contain a grayish white caseous material.

*No. 48.—Symptoms: Chronic cough for several months, nasal discharge very light from both nostrils, no ulcers visible. This animal was considered a rather doubtful case until after the autopsy, which demonstrated a very interesting lesion, the anterior face of the trachea, for a distance of 15 centimeters, was a mass of ulcers. The lungs were filled with glander nodules. No ulcers were found on the schneiderian membrane.

Nos. 49, 50.—These numbers represent the same animal, but different tests.

Symptoms: Bilateral nasal discharge during the past eight months, ulceration of the nasal membrane.

Lesions: Very characteristic ulcers in the nostrils, farcy buds

*See plate II.

—surface abscesses—have appeared since the last test, eight weeks previously, lungs normal.

Nos. 51, 52.—Symptoms : Chronic discharge from nostrils, nasal ulcers present, intermaxillary lymphatic glands nodulated.

Lesions : The membrane of the nostrils, septum and turbinated bones were covered with segregated ulcers, the lungs contained many nodules.

There were no pathological lesions of any of the internal organs of Nos. 48, 50 and 52.

No. 53.—Symptoms : A profuse yellowish-green catarrhal discharge from both nostrils, lymphatic glands indurated, ulcers present in both nasal chambers.

Lesions : Membrane throughout the nostrils, including the septum, turbinated bones and outer walls covered with ulcers, they also existed at intervals along the trachea, nodules of a pearly white color in the lungs, the contents of some of the nodules have become calcified.

No. 59.—Symptoms : The general symptoms of glanders prevailed, nasal ulcers and chordee lymphatics.

Lesions : Schneiderian membrane pitted with ulcers, the ulcers becoming more numerous in the upper portion of the nose, hard pearly colored nodules in the lungs.

Reviewing the twenty-five cases of glanders, it is found that six of them were affected with chronic cough ; in three the discharge came from the right, in five from the left and in fourteen from both nostrils, while in three there were no nasal symptoms, but instead skin symptoms were manifested, either as farcy buds or lymphangitis.

These observations indicate that the nasal discharge is not especially confined to the left nostril.

Nasal ulcers were present in fifteen. In the thirteen autopsied nodules were found in six of them and ulcers in the trachea of two.

Among the forty-three that did not exhibit any symptoms of disease, thirty-two gave no re-action whatsoever to the test, while eleven did, but with the eleven where this did happen glanders existed among the horses in the lot to which they belonged, so that it is not possible to state that the test was in error. This apparent variation of the test occurred in three out of nineteen

bands. A study of the records gives the following facts:

Nos. 2 to 11, inclusive, were the property of the same owner. In Nos. 2, 6, 8, 10 were observed symptoms of varied intensity, and all of them re-acted to the injection of mallein. No symptoms of any character of glanders was present in Nos. 3, 4, 5, 7, 9 and 11, yet Nos. 7, 9 and 11 gave typical reactions after the injections, not only in the rise of temperature, but also by the intense swelling which appeared at the point of the injection on the neck. These three animals were kept under close observation for nearly two years, and at no time did any symptoms of glanders appear. The owner of these animals resided on the same farm for four years after the test was made, during which period there was no recurrence of the outbreak.

Nos. 3, 4 and 5 gave no re-action.

The second case includes Nos. 53, 54, 55, 56, 75 and 76, in which the test was made seven months ago. No. 53 had characteristic symptoms of glanders, and it was simply to carry out the experiment and see if he would re-act that he was tested. The diagnosis made by the test was confirmed by the conditions found when he was post mortemed. The rest of the animals exhibited no symptoms, but only Nos. 54 and 56 did not re-act in any way. Nos. 55, 75 and 76 gave high temperature re-actions, but the swellings at the point of injection were not as painful as in typical cases. These animals were kept in a good stable and extra draughts were not present during the time the test was made. They are still under observation and up to the present time are to all external appearances healthy.

The last instance where this peculiar thing occurred was in Nos. 44 to 52 inclusive. Here 49-50 is the same animal, as is also 51-52, they being 49-51 made in the first test, which was made one week prior to the second, in which they are 50-52. In the first test they were the only animal tested, but in the second one all the animals were given the injection, and Nos. 44, 45, 47, 48, 50 and 52 re-acted. No. 46 did not give typical temperature re-action, as the temperature rose from 99.4 to 102.4 and dropping to 100.4 in four hours. In Nos. 44 and 45 the swelling at the point of injection was not characteristic of the mallein test, as it disappeared in a few hours and was not painful. Such, however,

was not the case with No. 47, in which the swelling was hard and painful and remained over the second day.

No symptoms of glanders has been seen in these horses up to the present time, although it is nine months since the test was given. New horses have been bought and kept with these and all of them appear healthy.

Did these horses have glanders in a latent form?

If they did, were they cured by the injection of mallein, or did they make a spontaneous recovery?

During this time of latency are they a source of danger to other horses, and should they be treated as dangerous to other animals?

These three cases occurred on farms where the horses could be well quarantined. They were necessary for farm operations, and after the forty days quarantine which was required, the owner desired to place new horses with these, which was permitted, but they were not taken from the farm for a longer period of time, the new horses being used for this purpose. In this way, these three cases have been utilized for the purpose of adding to our knowledge relative to the danger of the above described class of cases. The disposition of horses that present no external symptoms of glanders, and yet give a typical re-action to the mallein test, has long been a mooted question among sanitary officers and veterinarians, and has been the subject of much discussion. Some hold that the public safety demands that any horse re-acting to the test should be destroyed, as they may be latent centers for new outbreaks. Others believe that the individual owner as well as the public should be protected, therefore no animals should be destroyed unless they are positively dangerous, this being determined by whether or not there are external symptoms. The results obtained from the cases recorded above would tend to indicate that a conservative course can, at least sometimes, be wisely pursued.

In the seventy-six cases in which the test was made, sixty-six diagnoses were without doubt correct, and in eleven the diagnosis would be classed as doubtful. In no case was an incorrect diagnosis proven.

TREATMENT OF GLANDERS.

Glanders, like the other contagious diseases, has been a subject of great interest to scientists during the past quarter of a century, especially since it was definitely determined that the specific cause of it is the bacillus mallei. At the present time the interest of investigators is centred upon the possibility of obtaining a system of treatment which will result in recovery of at least certain animals affected with glanders, and they are therefore directing their attention in that direction, with the strong hope that they may in the near future reach a solution of this problem.

Many prominent veterinarians(1) of today are of the opinion that certain cases of glanders will recover under medical treatment, and(2) others report a few cases of apparently spontaneous recoveries.

It is not that treatment for some time to come would be practical in general sanitary practice, because of the time and expense which treatment might demand, but there are other instances where time and expense are of no object in securing a recovery. Especially is this true where a human life is involved.

It is not positively known if one attack of glanders followed by recovery produces immunity ; there is, as may be readily anticipated, very little evidence bearing on this phase of the subject. However, Nocard (3) believes that it does not.

With the varied results of several investigators before it, this station planned a series of experiments to deal with prospective treatments with mallein and to obtain data relative to the period of incubation or latency of, and the possible resistance of certain animals to glanders.

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- (1). W. C. Langdon, N. Dakota Station Report, 1898, pp. 29-32.
G. Fleming, Vet. Sanitary Science and Police, vol. I, p. 505.
E. Nocard, Deutsche Zeitschrift für Thiermedizin, Sept., '94.
- (2). V. M. Sulin, Arch. Vet. Nauk, St. Petersburg, 28 (1898),
No. 4, II pp. 119-122.
W. L. Williams, American Veterinary Review, July, 1897,
pp. 230-234.
- (3). Rec. Med. Vet., Paris, 8 sec. 6, 1899, No. 24, pp. 502-508.

Experiment 1.—To test the result of repeated small injections of mallein at short intervals, 1 c. c. to be injected and this repeated one week later. Lessen the succeeding periods, one day for each injection, until patient receives daily 1 c. c. of mallein, then increase the daily injection of mallein .25 c. c. The temperature is to be taken three times daily.

The animal selected for this test was a large gelding, thirteen years old, that had the following symptoms of glanders: Chronic cough, indurated lymphatic glands, and a not very profuse bilateral nasal discharge. He had given re-action to the mallein test made February 2nd, 1900.

		TEMPERATURE RECORD OF EXPERIMENT NO. 1															
	Amount in- jected and time of in- jection.	6 A.M.	7 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	12 M.	1 P.M.	2 P.M.	3 P.M.	4 P.M.	5 P.M.	7 P.M.	8 P.M.	9 P.M.	12 M.
Feb.	2	7 a.m.															
	*3	1 cc			101.1			101	101.1	102		103.3		104		104.2	104
April	12	1 cc	99.3		100.1	101.7	102		102.	102	100.4	102.4	103.3	101		103.2	
May	4	1 cc	99.1		99.4	100.4	102	101.1					99.2				
	5		99.2				103.1				104		105.1		104		
	6		102				101.3						101.2				
	7		99				101						100.				
	8		99.1				101						100.				
	9		100				101.3						101.1				
	10		100				101						100.3				
	11	1 cc	99.4		100		101		102.2		101.2		101.4	102.2		102	
	12		102.1				101.1						101				
	13		99.4				99.4						101				
	14		104.2				102.2						101.4				
	15		99.3				99.3						101				
	16		99				100.2						69.3				
	17		99.4				101.3						102				
	18	1 cc	99.4		100		100		100		101		100	99.4		99.3	99.4
	19		99				101						100				
	20		99.4				100.2						100.2				
	21		100				101.1						101				
	22		99				101						101				
	23		98.3				96						100.4				
	24	1 cc	100		102.3		102		101		102		102	103			
	25		100				101						100.2				
	26		101				101.1						102.2				
	27		101				101						101.2				
	28		100				100.4						101.2				
	29	1 cc	101		101.2		102.2		102				102.3	103			
	30		100.2				101						100.2				
	31		100				101						100.3				
June	1		99				101						101				
	2	1 cc	99.2				99.2						101				
	3		99.3				101						101				
	4		99				99.3						101				
	5	1 cc	99.5				101.3						102.2				
	6		100.1				100.2						102.2				
	7		99.3				99.2						100.1				
	8	1 cc	100				101.2						102				
	9		99.7				100						100.1				
	10	1 cc	99.4				100.2						102.1				
	11	1 cc	100				100.1						100.4				
	12	1.25 cc	100.1				100.3						100.6				
	13	1.5 cc	101.4				101.4						101.5				
	14	1.75 cc	100				101.3						101.1				
	15	2 cc	100				100.1						101				
	22	2.25 cc	99.2				100.4						101				
	23	2.50 cc	99				99.4						99.4				
	24	2.75 cc	99.1				99.4						100.1				
	25	3 cc	98				101						101				
	26	3.25 cc	99				101						101.1				
	27	3.5 cc	99				101.3						101.4				
	28	3.75 cc	99				101.3						100.2				
	29	4 cc	98.3				98						100				
July	1	4 cc	99				100.4						99.4				
	2	4.25 cc	99.1				100						100.3				
	3	4.5 cc	99				100.1						101				
	6	4.75 cc	99				100.3						101.4				
	7	5 cc	99				100.3						101.3				
	8	5.25 cc	99				100.1						99.6				
	9	5.5 cc	100.1				100						100.4				
	10	5.75 cc	100.2				100.2						101				
	11	6 cc	100				100.2						101.1				
	12	6.25 cc	100.2				101.4						102				
	13	6.50 cc	101				101.3						101.7				
	14	6.75 cc	100.1				101						102				
	15	7 cc	100.4				102.3						102				

* A definite swelling at point of injection disappears one week after infection.

† Swelling from injection disappeared in about five days; nasal discharge increased.

After July 15th, when the injections reached 7 c. c., the supply of mallein was exhausted, and the injections consequently discontinued. During the time of these injections, he apparently lost in flesh, but as soon as they were discontinued his appetite became better and he rapidly gained what he had lost. The temperatures taken from this date until late in November, at no time showed any marked elevation. He was found dead* in the corral one morning, although the evening before he appeared in his usual health. Within a few hours the post mortem was held; his lungs were partially filled with pus and calcified nodules, and the nasal mucous membranes plentifully studded with ulcers.

Experiment No. 2.—To test the result of small injections of mallein at long intervals, one c. c. to be injected monthly; temperature to be taken three times daily, the week before and after the injection is made. The day of the injection, temperature to be taken every two hours. The symptoms manifested by the animal for this experiment were a discharge from both nostrils, chronic cough, swollen intermaxillary glands, and a lymphangitis of the left posterior leg. He had been given the mallein test early in the year, and had at that time given a typical re-action. He was not at any time during the experiment in very good flesh, although his appetite was generally good.

*His death was probably due to some other cause than glanders. When found in the morning he was greatly bloated. The lesions seemed hardly severe enough to cause such sudden death.

		RECORD OF MALLEIN TEST OF FEB. 3RD AND APRIL 12TH.																
		Amount injected and time of injection.	6 A.M.	7 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	12 M.	1 P.M.	2 P.M.	3 P.M.	4 P.M.	5 P.M.	7 P.M.	8 P.M.	9 P.M.	12 M.
Feb. 2	7 a.m.									100.4								
*3	1 c c					100.2			100.3		100.2		104.1		104.3		104.1	104
4			103															
April 11										101.4	102.2				101.2			
†12	1 c c	99.2		100.2			101		103.1		104			104.3	103.4		103.2	
13							101.3											
Temperatures of the day of and the day before and after the injection during the experiment.																		
May 4			99.3	101				101.2						101.3				
5	1 c c		102.1		102		103		103.3		104			102.3	101.4			
6			102				103.1							103.2				
June 8			102				102.1							102				
9	1 c c		99.4		101		101.2		102		103.1			103	103.4			
10			98.4				100.1							100.1				
July 10			101.2				101.2							101.3				
11	1 c c		100.1		100.8		102		104		104.2			104.2	104			
12			100.1				101							101				
Aug. 16			99.5				101.7							101				
17	1 c c		99.8		100.6		102.3		103.5		103.8			103.6	103.5			
18			100.2				100.5							101.3				
Sept. 14			99.8				100.5							100.7				
15	1 c c		101		100.3		102		102.7		103.1			103.8	103.6			
16			102.4				103.8							103.5				

* Large swelling, very sore, entirely gone within week after injection.

† Characteristic swelling, with disappearance in about five days.

AVERAGE WEEKLY TEMPERATURES.								
Date.	Before inject'n.			After injection.				
	7	11	5	7	11	5		
	A.M.	A.M.	P.M.	A.M.	A.M.	P.M.		
May 5				99.7	101.1	101		
June 9	100.3	100.7	101.1	99.5	101.1	101.1		
July 9	99.4	100.4	100.5	99.9	101.4	101.4		
Aug. 18	99.4	100	101.2	100.2	101.3	101.6		
Sept. 14	100.1	100.3	100.9	102.2	103.2	103.5		

Three days after

The animal's death,* on September 18th, brought the experiment to a close, after having been carried on for nearly five months. The average temperature registered higher the week following the injection than the week before. Such small injections of mallein at such long intervals seem to have had no apparent effect, either positive or negative.

Lesions observed at autopsy : Body fairly well nourished. Left hind leg much swollen, and a few farcy buds are present ; these are filled with the characteristic viscid pus of farcy. Ulcers are quite plentiful in the upper part of the air passages, even down to the trachea, but none are seen in the lower part of the nostrils. The lungs contain a few nodules, but not so many as would be expected, considering his chronic cough. It is possible that this cough was caused to some extent by the tracheal irritation. The other internal organs are normal.

Experiment No. 3.—This included the injection of mallein at monthly intervals, the first amount to be injected to be 1 c. c., this amount to be doubled each succeeding month. The temperature is to be taken three times daily, the week before and the week after the injection is made, while the day of the injection the temperature shall be taken every two hours. A large mule, belonging to a band of animals showing symptoms of glanders, and in which a number, including this mule, had re-acted to the test, was selected for use in this trial. It showed a slight secretion from the nostrils, enlarged lymphatic glands and ulcers in the nostrils. There was lymphangitis of the left anterior leg, and about the knee of this leg a number of small peculiar eruptions were seen ; these eruptions were hardly characteristic farcy

*We are unable to state the cause of death. It may have been due to the glander lesions.

nodules, but more like the ulcers seen in the heat eruptions of summer. The experiment continued until July 16th, when he was found dead* in the corral. Post mortem shows both nares to be the seat of intense suppurative inflammation; the septum nasi extensively ulcerated, numerous small abscesses in both lungs. There is an abscess in the lymphatic gland of the left posterior leg. A quantity of material from one of the lung abscesses of this mule was used to inoculate another animal for experiment No. 6.

*This animal without doubt died from glanders.

		TEMPERATURE RECORD OF EXPERIMENT NO. 3																	
		Amount in- jected and Time of in- jection.	6	7	8	9	10	11	12	1	2	3	4	5	7	8	9	12	
			a.m.	a.m.	a.m.	a.m.	a.m.	a.m.	m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	m.	
Feb.	5	7 a.m.								101.2									
	6	1 c c							101.2		102.2			103.3	104		104	104	
	7			103															
April	11			99.4				101.3						100.5					
	12	1 c c	100		100.2		100.3			103.2		104		104	104.4		104.2		
	13							101.4											
May	4		102.2			99.4				99.3				99.2					
	5	2 c c	101.1			100				100.1		103.4		105.4	105.4				
	6			103.7										104.3					
June	8			103				102.3						103					
	9	4 c c		99.4		100.1		101.1		101.2		102		102	103				
	10			99.2		100.1		100.1						100.1					
July	9		102					102.2						104					
	10	8 c c	101		101.2			102.2		102.4		102.2		103	103.2				
	11		103					103						104					

AVERAGE TEMPERATURES.

February.—	Day before injection.....	Day of injection.....	103	Day after injection.....	—
April.—	" " ".....	" " ".....	102.6	" " ".....	—
May.—	" " ".....	" " ".....	103.8	" " ".....	103.5
June.—	" " ".....	" " ".....	101.2	" " ".....	99.8
July.—	" " ".....	" " ".....	101.9	" " ".....	103.3

AVERAGE TEMPERATURES.

	Week before day of injection.			Week after day of injection.		
	7 a. m.	11 a. m.	5 p. m.	7 a. m.	11 a. m.	5 p. m.
May.—				101.7	102.0	102.5
June.—	101.1	101.1	101.6	100	100.6	100.6
July.—	101.5	101.5	103.5	102.2	102.4	103.2

The injections of February and April were made for diagnostic purposes. The Temperature chart shows that after the June injection of 4 c. c., there was a decided fall of temperature during the day the injection was made. The temperature after this injection was much lower than the day before the injection. The average temperature of the July day of injection is also lower than that of either the preceding or following day.

During the last month the animal lived, the evening temperature averaged nearly two degrees higher than the morning temperature. The week's average after the 4 c. c. injection was one degree lower than the week's average before it, but after the 8 c.c. injection the average temperature for the week prior to the injection was one-half degree lower than that of the week succeeding the day of test.

Experiment No. 4.—In this experiment the mallein is to be given at weekly intervals. The first is to be one c. c., and the dose injected is to be gradually increased one c. c. each succeeding week. The temperature shall be taken three times each day except the day of the injection, when it shall be taken every two hours.

The animal that was used here was a small mule affected with glanders, in which the symptoms were so characteristic and well marked that it was not thought necessary to give it the mallein test until in April, just prior to the experiment. It was exceedingly well nourished and had a good appetite. The nasal septum was considerably swollen, enough so that it caused difficulty in breathing. From the time that this animal was placed in the experiment it gradually lost its appetite, and when it died, June 27th, it was little more than a skeleton.

After death, glander tubercles were found in both lungs, there was almost complete destruction of the nasal septum and the turbinated bones; ulcers extended into the pharynx and larynx.

This subject did not at any time give a very marked reaction to the mallein; its temperature was continually very high, both before and after the injections were made. The tabulated temperatures show that the average evening temperature was higher than the morning temperature.

He practically starved to death, as the lesions were so severe that he was unable to obtain sufficient nourishment.

		TEMPERATURE RECORD OF EXPERIMENT NO. 4																
		Amount in- jected and Time of in- jection.	6	7	8	9	10	11	12	1	2	3	4	5	7	8	9	12
			a.m.	a.m.	a.m.	a.m.	a.m.	a.m.	m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	p.m.	m.
Apr.*	11	7 a. m.									101.3		103.2		103.4			
	12	1 c c	102.3		102.3		102			103		102.3		103.2	103.4	103		
	13							102.2										
May	4		99.3				102		101.4					102.3				
	5	1 c c	102.2				103		102.1			103.4			102.4			
	6			104.8				105						106				
	10			102				101						102.3				
	11	2 c c		102		102.1		102		102		103.1		104	103.2			
	12			103				103						103.4				
	17			101.2				102.2						101				
	18	3 c c		101		102.2		102.3		102		102.3		102.1	103	103		
	19			103				102.3						102.1				
	24			102				104						104				
	25	4 c c		101		101.3		104		103.4		103		103.6	103.3			
	26			102.2				103.4						104				
	30			103				103.1						103				
	31	5 c c		103		102.2		103		104.1		103.2		103.4				
June	1			103				103.1						103.1				
	8			102				103.1						103.1				
	9	6 c c		103		103.1		102.3		103		103.4		103.3	103.4			
	10			102.1				102.3						102.3				

AVERAGE TEMPERATURES.

Date.	Week before the day of injection.			Week after the day of injection.		
	7 a. m.	11 a. m.	5 p. m.	7 a. m.	11 a. m.	5 p. m.
May 5.....				102	102.8	102.5
11.....	102	102.8	102.5	102.9	102.2	102.6
18.....	102.9	102.2	102.5	102.1	102.7	103
25.....	102.1	102.7	103	102.1	103.1	103.6
31.....	102.1	103.1	103.6	103	103.1	103
June 9.....	103	103.1	103	102	102.5	102.7

* This animal had a very large and painful swelling at the period of injection.

DIRECT EXPOSURE.

Experiment No. 5.—An aged gelding that had been tested for glanders and had failed to re-act, was, July 17th, 1900, turned into the corral with two glandered horses. At the same time, a third horse, which had been experimentally inoculated with supposed glander material, was placed in the enclosure, so that really, as was later proven, the gelding was kept with three glandered animals. He ate out of the same manger and drank from the same barrel as the others, so that he was given every opportunity to contract the disease. His temperature was registered three times daily. The temperature record shows that at no time up to September 14th did his temperature run above 101.3. He was at this date given an injection of 1 c. c. mallein, but did not

re-act. During October he was given a second test, but again without re-action. December 1st, he was shot. No lesions of glands were found in any of the organs. This animal had for four months been kept in constant contact with animals that had glands in different degrees of severity, and yet at the end of three months he did not respond to the mallein test, and one month later no pathological lesions were in evidence. This is only one instance, but we deem it worth recording.

DIRECT INOCULATION.

Experiment No. 6.—A two-year-old filly was obtained and used for this experiment. She was tested with mallein without any elevation of temperature resulting. June 17th, 1900, a quantity of the contents of one of the lung abscesses from the animal used in Experiment No. 3, was rubbed into the schneiderian membrane. This was done with a small bristle brush. Prior to this date, her temperature had been taken and averaged a small fraction over 100 degrees. On the evening of the following day, her temperature rose to 103; the next morning it was down to 101.2, but in the evening it was 103.3. From that date until she died the temperature averaged for morning 101.8, noon 103.5, and evening 104. She died the morning of November 28th, 1900, and the autopsy was held a few hours later. The lesions were characteristic of glanders; there were a large number of ulcers over the entire nasal surface, the septum was necrosed at the point of inoculation to such an extent that there was communication between the nostrils; lungs normal; in the mucous coat of the stomach and extending into the muscular coat were a number of small nodules filled with a thick, yellowish-white pus. The serous coat of the intestines was very hyperaemic. No skin lesions visible. Judging by the thermal rise of the second day, the period of incubation in this case was about thirty-six hours.

The results obtained from Experiments 2, 3 and 4 were negative, the three subjects dying while they were still being treated. In No. 1, although the result was negative, still the thermal indications were favorable while he was under treatment, and immed-

ately after the injections ceased he rapidly gained in flesh. Had it been possible to have resumed the injections, the result might have been different. No. 5 gives valuable data in showing how some animals, especially in this western country with its peculiar climatic conditions, may continue immune even when subjected to constant exposure. In No. 6 there is simply additional information relative to the period of incubation. Most authors give the time from three to seven days. In this case, the period being so much shorter may possibly be accounted for in part by the age of the subject, she being only two years of age.

All these animals were kept in an open enclosure, a shed roof over one corner to offer them some protection against the weather. They were fed all the grain hay they would eat, but no grain. Water was kept so that they could obtain it at any time.

POPULAR INFORMATION ABOUT GLANDERS.

Glanders is a disease that has been recognized since a very early time. It is mentioned in the writings of some of the early Greek and Roman writers. That glanders is a specific contagious disease is now recognized and admitted by all veterinary investigators and writers. Even as early as the latter part of the eighteenth century the fact that glanders could be conveyed from one animal to another was established, although not generally admitted. However, in 1868, it was again demonstrated, and has been accepted by the majority of investigators. Since that date, evidence to fully establish the correctness of the above conclusions, as stated by those early workers, has continued to accumulate.

Cause of Glanders.

The germ which is the specific cause of glanders is the bacillus Mallei, which was discovered in 1882 by Löffler and Schutz. It is described as a bacillus which is generally straight, although it may be slightly curved, having rounded ends. In most instances it is single, but when grown on certain foods, it is united into chains or filaments. It is killed by being subjected to a temperature of 55° C. (131° Fahrenheit) for ten minutes, or it may be

destroyed by a five per cent. carbolic acid solution, or one of corrosive sublimate 1-5000,—that is, five parts of carbolic acid to one hundred of water, or one part of corrosive eubliminate to five thousand parts of water. There are other disinfectants that readily destroy the balillus, but in practice they are not quite as satisfactory as the two mentioned. The germ will live in moist material for about four months,—for instance, in the nasal discharge deposited in the cracks of the wall of the stall or manger by an affected animal. When the bacillus is exposed to alternate heat and cold, it readily loses its virulence, or power to produce disease.

Animals Affected by Glanders.

Glanders is principally seen in the horse and ass, but occasionally it is met with in other animals. Man is not exempt from it. It is readily produced experimentally in the dog and guinea pig. The ox is considered not to be subject to glanders.

Mode of Transmission.

Glanders is probably conveyed from one animal to another through some direct means of inoculation, as the direct contact of a well animal with a diseased one. This statement is supported by the observation that it is most often the diseased animal's mate or stall neighbor that becomes affected, and not the animals farther away from him,—that is, in those stables where animals are kept fairly well by themselves, glanders does not spread promiscuously through the stable, but rather confines itself to a local area. It may also be spread by means of the various horse and stable paraphernalia, such as harnesses, neckyokes, curry combs and brushes, watering pails and troughs, mangers and feed boxes. It is also possible for men who are careless in handling glander patients to carry the germs on their hands or clothing from one animal to another. By these means glanders is spread in a stable. New centres of infection may occur in the same way, as well as through the means of public hitchracks or posts, upon which the infectious material is deposited by one animal and which later infects another.

Symptoms.

This disease occurs in two forms: the internal, which is known as glanders, and the external, a skin form which is called farcy. Either one of these may be either acute, running a rapid course, or chronic, and affect the animal for years. The latter is the one generally seen. In acute glanders, symptoms of great intensity are noticed, shivering fits followed by high fever, an unthrifty looking, staring coat of hair, loss of appetite, and a very rapid falling off in flesh. A little later, there is seen in the nostrils small ulcers, which may be separated from each other, but often they run together and form large raw surfaces, losing their characteristic appearance. With this comes a nasal discharge, considerable in quantity, of a yellowish-grey color and very sticky, giving the animal a disgusting appearance. The glands under the jaw are swollen and seem to be fastened to the bone, but which they are not. The animal rarely lives longer than two or three weeks, often not even that long, because the owner becomes frightened at the severity of the symptoms and if possible obtains the services of a veterinarian, who makes the diagnosis and advises the destruction of the animal. The symptoms in chronic glanders may vary from the unobserved watery discharge to symptoms nearly as severe as in the acute form. The animal may live for a long time without any apparent change in its condition. It may be fat, in good spirits, have a good appetite, and be practically without any fever. As before stated, the least symptom may be a slight watery discharge, hardly noticeable, which may increase to the very characteristic discharge of a sticky greenish-yellow matter, from either or both of the nostrils, associated with swelling of the glands under the jaw and the characteristic ulcers in the nose. These ulcers have a very sharp edge, as if cut with an instrument, and at the same time the bottom of it is pushed upward so that it is nearly on the same level as the surrounding tissue. These ulcers are generally by themselves, but may run together, forming a large surface. They are found even in the trachea or windpipe. Nodules or small abscesses are found in the lungs; when this occurs, the animal will have a chronic cough.

Farcy, which until the past few years was supposed to be a separate disease, is simply a form of glanders. If an animal is infected with material from either farcy or glanders, it is impossible to tell beforehand what form he will take; he may take farcy from glanders, or glanders from farcy.

The difference in the symptoms of acute and chronic farcy is simply a matter of an intense fever ushering in the former and the rapid development under the skin of a large number of peculiar abscesses, while in the latter the fever will be unnoticed and only a few abscesses will form on the various parts of the body. These abscesses, or farcy buds as they are popularly called, vary in size from a pea to a half English walnut; they are from one-fourth to one and one-half inches in diameter. They appear quite suddenly and without any perceptible inflammation of the surrounding tissue, so that their form is quite distinct and their edge well defined. If the same sized abscess should form from any other cause, a considerable amount of swelling would be present and the edge would not be well defined. The nodules or buds soften, the skin breaks, and they discharge a thick pus, which sticks together and will often roll down the hair without leaving much of a trace of its course. The ulcer formed from a nodule is very characteristic, in that the bottom of the ulcer cavity is larger than the top, and therefore the sides slant upwards and inwards, instead of upwards and outwards, as in common abscesses. Farcy ulcers, especially in the chronic form, often show a tendency to heal, leaving a small scar which does not cover over with hair.

Glanders and farcy may be present in an animal at the same time.

Mallein.

There are several ways in which mallein may be prepared. The most common one is to grow a culture of *bacillus mallei* in what is known as peptonized beef broth, to which has been added 5 per cent. glycerine. This culture is placed in an incubator and kept at a certain temperature for a number of days varying from three weeks to two months, after which the culture is filtered through a Pasteur or a Kitasato porcelain filter. This removes the bac-

teria present in the liquid, so that the resulting filtered liquid is practically sterile. However, to make such condition absolutely certain, the liquid is sterilized by heating it for about twenty minutes daily for three consecutive days by means of steam under pressure, after which it is mixed with its volume of glycerine, which increases its keeping qualities. The mallein, as furnished by the Bureau of Animal Industry, United States Department of Agriculture, is a clear pale-yellow fluid, slightly sticky because of the glycerine there is in it. Mallein contains certain materials which possess the property of causing considerable rise of temperature when it is injected into an animal in whose body the glanders bacillus is present.

Mallein Test.

The injection of mallein into an animal and the observation of the temperature of such animal for a certain period of time before and after the injection, is called the mallein test. When the temperature remains nearly normal after the injection, the test is negative; if, however, there is a considerable rise of temperature, the test is positive, and that condition is spoken of as a re-action.

The test is carried out in detail in the following manner: The temperature of the animal to be tested is taken in the morning, at noon, and again in the evening. These three temperatures will indicate the average normal temperature of the animal. The following morning at 7 A. M. one cubic centimeter (15 drops) of mallein is injected under the skin, generally of the neck. Every two hours during this day the temperature is again taken and carefully noted. If there is no rise in temperature the animal is considered free from glanders, but if there should be an elevation of temperature of from 1.5° to 4° glanders is judged to be present. In addition to this elevation of temperature, there will appear at the point of injection on the neck a large, hard, flat swelling, about 10 to 12 centimeters (five to six inches) in diameter, and which swelling remains for a number of days.

The mallein test is possibly not infallible, yet it is as a rule so reliable in the hands of competent men that its use is being officially recognized in many countries.

Eradication of Glanders.

Considering the present general inefficiency of treatment for glanders, its probable spread to other horses, and its possible transmission to man, its existence is a serious menace and its eradication a problem demanding careful consideration. It previously has been shown in this bulletin that glanders does not spread promiscuously through a stable full of horses; this is a point of great advantage to the sanitarian. The process which will successfully eradicate an outbreak of glanders includes three steps, which must be conscientiously performed. They are the destruction of affected animals, the placing of exposed animals in quarantine, and the thorough disinfection of stables or quarters where the diseased animals have been kept. The glandered horses should be shot and buried, those that have been exposed and show no symptoms of glanders should be quarantined. The period of quarantine varies in different states, in this state forty days being considered a sufficient length of time to keep an animal isolated.

Disinfection also varies in detail; we use and would suggest the following method of procedure: The tearing out and burning of all loose mangers and pieces of partition, the removal of the straw and hay that has been used about the animal. About two inches of the dirt of the stall, if it has a dirt floor, is scraped off and hauled out and the material to be burned is put on top of it; the heat from the fire will thoroughly disinfect this earth. The inside of the stable, woodwork, etc., is washed with a five per cent. solution of carbolic acid, or 1-1000 corrosive sublimate solution. Four days later this is repeated with a hot saturated solution of either iron or copper sulphate, (copperas or blue vitriol), and four days later everything is white-washed. A spray pump is used in this work, which makes it less laborious and it is also better done as the disinfecting material is sprayed into cracks and over the surface of the floor. It is rarely that the destruction of an entire stable is necessary. After the stable is disinfected it is wise to leave it unoccupied by horses for about two or three months, or it may be used for a cow or calf barn. By such a system as this it has been possible to eradicate glanders from a farm where it had existed for several years, and where a number of horses died annually from the disease.

Description of Plates.

PLATE I—Nasal Septum showing the characteristic ulcers of Glanders. The peculiar upheaval of the membrane is visible in a number of instances.

PLATE II—Section of Trachea from patient of Mallein Test No. 48. The anterior face of the Trachea is nearly completely covered with ulcers. This is of especial interest since no ulcers existed on the nasal mucous membranes.

PLATE I—*Colored*—Nasal Septum showing acute lesion.

PLATE II—*Colored*—Middle section of Nasal Septum, right side showing ulcers.

PLATE III—*Colored*—Middle section of Nasal Septum, left side showing scars where healing of lesions has taken place.

Acknowledgements.

The details of the foregoing experiments were carried out by Drs. A. Kolling and C. L. Barnes, assistant veterinarians at the College, under the direct supervision of the author.

I also wish to acknowledge my appreciation of the kindness of Dr. John R. Yocum, of Tacoma, for a number of bacteriological examinations of subjected material made, and to Veterinarians J. T. Lee of Tacoma, and James Bullivant of Spokane, for Mallein tests made and recorded.

The Mallein used in these tests was kindly furnished by the Bureau of Animal Industry, Department of Agriculture.

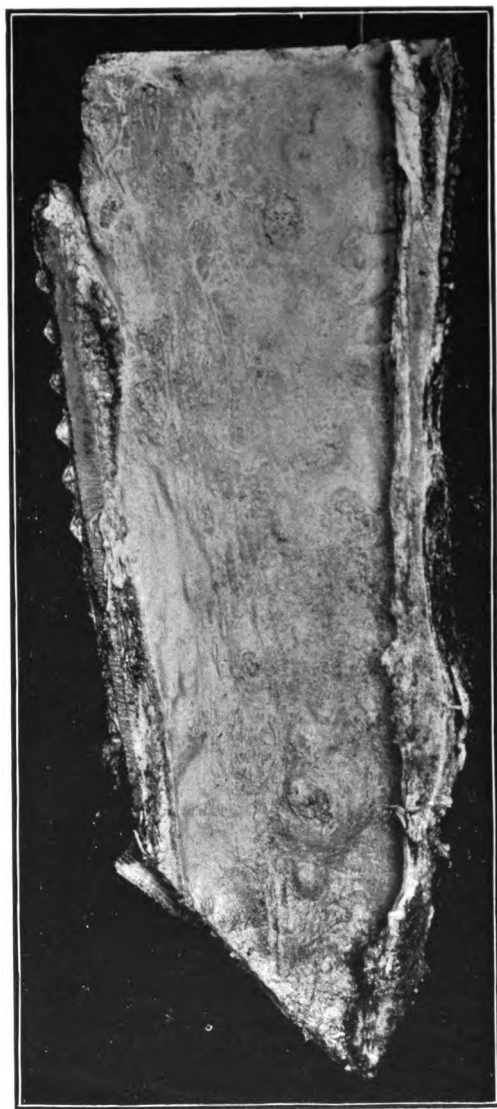


Plate No. 1

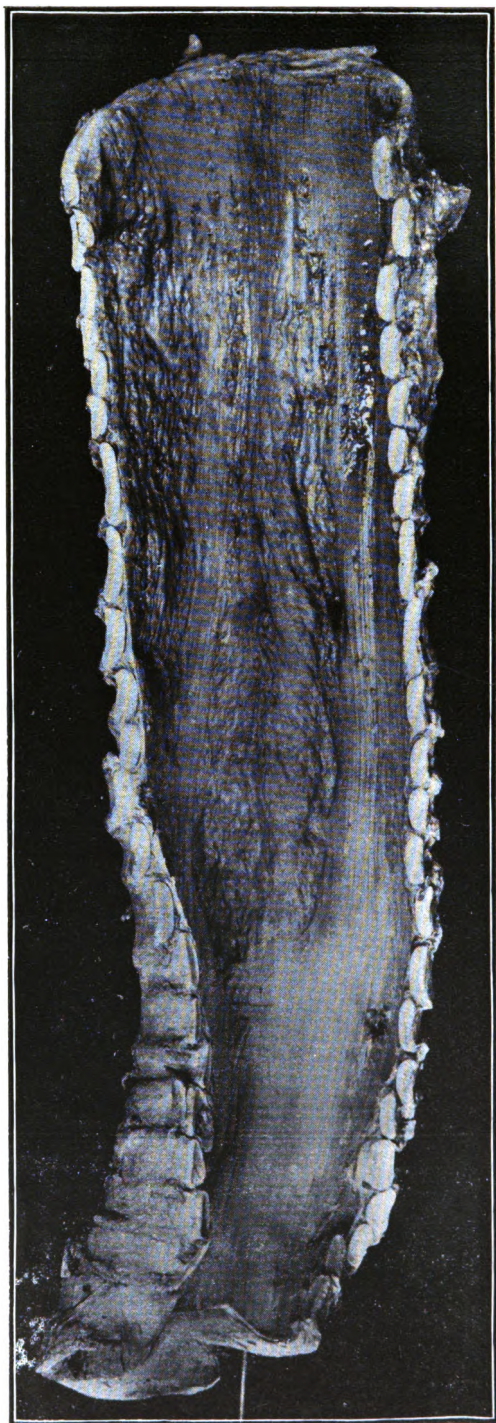


Plate No. II



Haines, del.

GLANDERS.

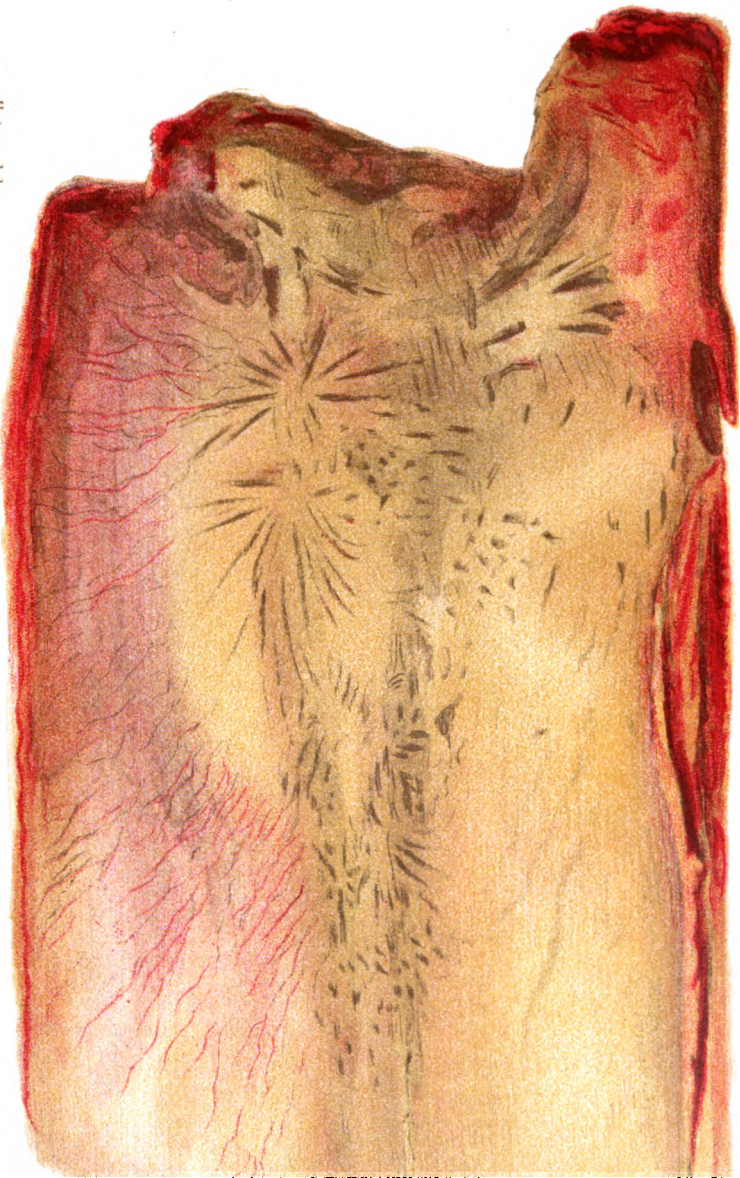
Transverse section of horse's thigh & side, showing acute Glanders.



Haines, del.

G. ANDERS.

Middle region of nasal septum, both sides, showing others.



Haines, del

GLANDERS.

Posterior half of masted squirrel, right side, showing cutaneous.

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WASHINGTON STATE AGRICULTURAL COLLEGE
AND
SCHOOL OF SCIENCE

EXPERIMENT STATION

PULLMAN, WASHINGTON

Bulletin 51

Department of Horticulture

Locating Orchards in Washington

By S. W. Fletcher

1902

All bulletins of this station sent free to citizens of the state on application to the
Director.

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LOCATING ORCHARDS IN WASHINGTON.

BY S. W. FLETCHER.

The state of Washington is rapidly winning for itself a prominent place among the great fruit producing states of the country. This is due in a large measure to its remarkable diversity of soil and climate, which offers a great range of conditions for the adaptation of different fruits and different varieties. In the main, the commercial orchards of Washington have been profitable, when they have been grown as a business proposition and cared for in a business-like way. The outlook for the future is good, especially when fruit growing is made the main line of work in a limited system of diversified farming.

The orchard area of the state is increasing ten to fifteen per cent. annually, particularly in the planting of winter apples east of the Cascade Mountains. There is a constant demand for information on the subject of the location and planting of orchards, from business men who seek a safe investment for their capital, from farmers who desire to diversify their farming, and from the thousands of homeseekers who cross our borders every year. This bulletin is prepared to meet this demand. It is a brief discussion of the problems which confront the man who proposes to plant an orchard in the state of Washington, and points out how he may solve these problems for himself. The practical details of orchard planting, such as soils, sites, nursery stock, etc., are considered in Bulletin No. 52 from this Station.

I—Have a Plan.

The most important point of all in the location of an orchard is the point of view of the man who proposes to do the planting. He should have a plan. Much of the unsatisfactory results

in farm work of every kind is due to the lack of a definite plan. Especially is this true in the fruit-growing of Washington, because of its great diversity. A large proportion of the unprofitable orchards in the state were planted by men who rushed into the business without adequate plans or preparation. Commercial orcharding in Washington is now, and will continue to be a profitable business when intelligently conducted; but the man who takes up fruit-growing without definite plans about what he ought to do, and how he is to do it, will probably inform us some years later that "fruit-growing don't pay." Success in fruit-growing, as in any other business, is a very personal matter. Fruit-growing pays when the fruit-grower makes it pay. One way of making it pay is to start right in the beginning. Before a tree is bought or a variety selected, the business orchardist will ascertain the comparative merits of different localities for producing different fruits. He will find out where he can market his fruit at a profit after he has grown it. He will ask fruit shippers and commission men what types of fruit are in greatest demand. He will inspect profitable orchards, and ask many questions of the owners. In short, he will try to inform himself on all the practical points involved in the intelligent planting of orchards. When all the evidence is in, he will decide what is the best opening for himself, and then lay his plans. The evidence from a thousand orchards in this state is that fruit-growing is most likely to be profitable when the grower has a well worked-out plan in the beginning. There are too many orchards planted at a hazard.

II—Study the Problem of Fruit Zones.

Commercial fruit-growing is becoming more and more localized. We are learning that each fruit, and even each variety, require special conditions of soil and climate for their most perfect development. In the home orchard we may grow a large number of varieties of many kinds of fruits, because there it is not necessary that each tree shall return a money profit. But in the commercial orchard everything must be figured on the dollar and cent basis, and only those fruits or varieties grown which are best adapted to the place and hence are most likely to be profitable. In locating his orchard, therefore, the planter should make a care-

ful study of "fruit zones," or the regions which are best adapted for the culture of certain fruits. These are so clear-cut in the state of Washington that no mistake need be made here. For example, if he has decided that his greatest profit will be in growing long-keeping winter apples and pears, he will probably investigate most carefully the uplands of Eastern Washington where the conditions of soil and climate are such as to develop long-keeping qualities in fruits. If early apples, early pears or peaches are most promising, he will compare the merits of the Yakima, Wenatchee, Snake River, Walla Walla, and other warm valleys in Eastern Washington. If he is convinced that there is money in prunes, naturally he will be first attracted to Clarke county. Should he be enthusiastic on small fruits, he will visit the Puget Sound country; and so on.

The point is not what fruits can be grown in a given section, but what fruits can be grown best. It is entirely possible, for example, to grow prunes in the uplands of Eastern Washington, and some men have found them fairly profitable; but winter apples are generally so much more profitable that it would be very unwise to encourage the planting of prunes in that section, except for home use. The uplands of Eastern Washington cannot compete with Clarke county in growing prunes; neither can Clarke county compete with the uplands in growing winter apples. Then let each section grow the fruit which is best adapted to its conditions. Again, winter apples can be grown, and are grown, in many parts of the state which are better adapted for early apples, Bartlett pears or peaches. In many cases this is apparently justified, for other factors may combine to make winter fruits more profitable, even in those sections which are better adapted for summer fruits. The problem of fruit zones should always be studied in connection with the economic problems of markets, transportation, and cost of production. The general principle is that the commercial orchard should be located in that section where the fruits to be grown will reach their most perfect development; the special exception is that cost of land, nearness to market, facilities for transportation, and other economic problems may often be of such weight that it will pay to locate an orchard outside its most congenial climate. A full discussion of the adaptation

of different fruits to the several horticultural sections of the state will be presented in a later bulletin entitled "A Horticultural Survey of the State of Washington."

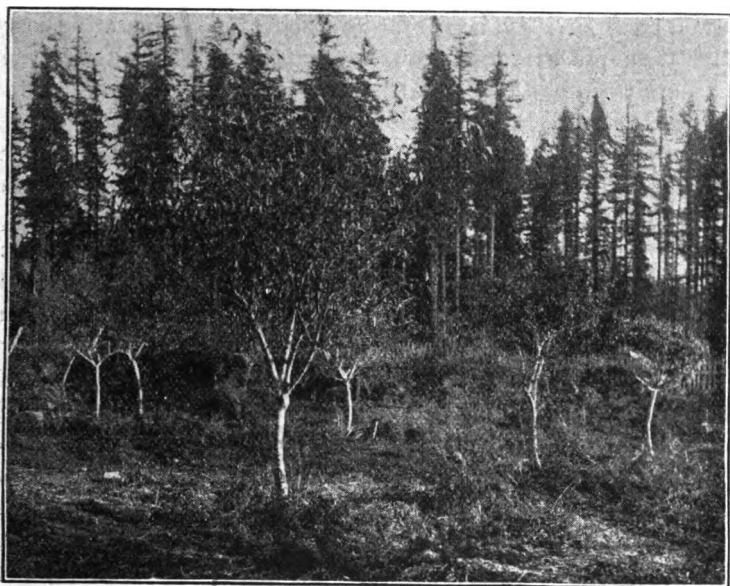
III—Locate Within Reach of Good Markets.

It is very unwise to plant a commercial orchard in any location until reasonably sure of a good market for the produce. The common mistake, and a very unprofitable one, is to locate the orchard first and hunt for a market afterward. Unquestionably the most difficult problem which the Washington fruit-grower must face is how to market his fruit at a profit. He has usually no difficulty in growing fine fruit, but often he has difficulty in selling that fine fruit to advantage. Before deciding on a location for his orchard, therefore, the planter should carefully investigate the possible markets for the particular fruits he proposes to grow. The problem is two-fold—where to sell the fruit at a profit and how to get it there safely and cheaply. When quickly perishable summer fruits are grown, as peaches, cherries, early apples, and pears, it is of far greater importance that good markets be easily accessible than when winter fruits are grown. The grower of winter fruits has a longer season in which to dispose of his produce, and may often be practically independent of the market if he provides himself with storage cellars. It may be stated as a general rule in the location of orchards that the more perishable the fruit grown, the closer should be the orchard to a number of good markets, and the better should be the transportation facilities.

If possible, it is a good plan to locate where there are two or more ways by which fruit may be carried to market; as two competing railroads, or railroad and water service. Competition tends to reduce freight rates to a lower point than is usually reached when one line has a monopoly of the transportation.

The location of an orchard will also be influenced by the character of the market, whether personal or general. The orchardist has a personal market when he sells his fruit directly to the consumer, or to retail merchants in a near-by town or city; he has a general market when he sells it to a fruit shipper or sends it to commission men in the great distributing centres. Most of our

Washington fruit is now necessarily placed upon the general market; but with the growth of our cities will come a corresponding increase in the opportunities for securing a personal market, which is usually more profitable if well handled. If the planter intends to cater to a local trade he will locate his orchard as close to the city as the price of land will admit; if he intends to grow staple varieties for the general market he will locate further out in the country, where land is cheaper.



"Fruit-growing Don't Pay."

IV—Keep Down the Cost of Production.

The manufacturer knows that he must reduce the cost of producing his goods to the lowest possible notch, if there is to be any profit in the business. The successful fruit-grower must be a business man, and follow business principles. In this country of distant markets and heavy freight bills, which so often eat up a large percentage of the sales proceeds, there is especial need of emphasizing the importance of great economy in producing fruit.

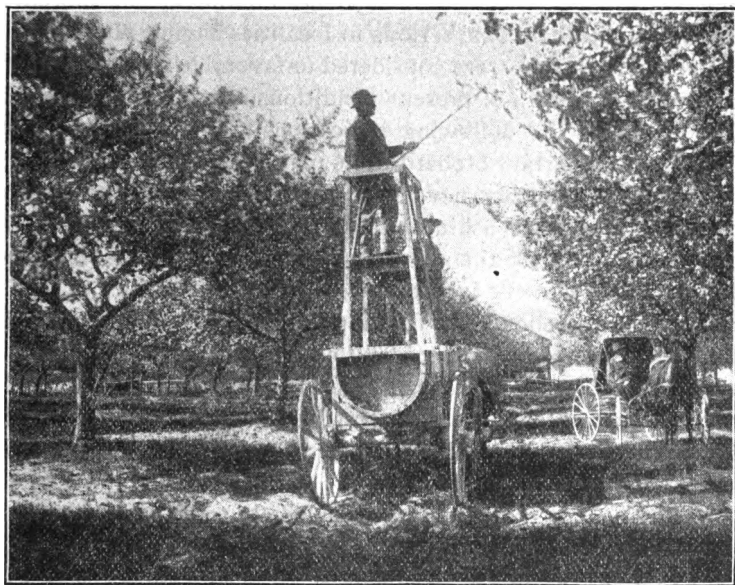
There seems to be a general, although fluctuating, tendency towards lower prices for fruit. The increase in our population and the broadening of our markets will tend to hold up the price, but it is the writer's opinion that this increasing demand cannot be expected to entirely offset the increasing competition. Those who are planting orchards today must look forward to the time when the extra profits of fruit-growing will come only to the man who can put fine fruit on the market at the lowest possible cost. There are many phases of this subject which the fruit-grower should consider, such as the cost of labor, the comparative cost of cultivation and irrigation, etc., but so far as it affects the location of an orchard, but two will be mentioned here—the cost of land and the cost of fighting injurious insects and diseases.

In a preceeding paragraph mention was made of the fact that orchards of the more perishable fruits, and fruits grown for a personal market, should be located nearer the cities than orchards of winter or general market fruits. This means that the cost of the orchard site will be greater, and that the selling price of the product must be enough higher to pay for the additional cost of production in tied-up capital. For example, we would be more likely to make money by planting peaches, plums, or early apples and pears on land costing \$150 per acre, situated near a good city market, than we would to plant this land to winter apples. The summer fruits demand near-by markets, and will be more apt to pay for the extra cost of production than winter fruits, which will grow as well on land costing \$25 per acre and do not demand near-by markets.

One should also consider the cost of clearing land and fitting it for orchard planting. It will be readily seen that the Puget Sound orchardist who expends \$100 to \$200 per acre in clearing his land of stumps must get considerably more for his fruit, if his fruit-growing is to pay, than the Yakima orchardist who clears his land of sage brush for \$5 to \$10 per acre. For these and other reasons which increase the cost of production, it would seem that the Puget Sound orchardist would generally find more profit in catering to the local demand in Sound cities for perishable summer fruits, than in trying to compete with the Eastern Washington orchardist, who can produce

the staple varieties of winter fruits much cheaper.

Another point to have in mind is the distance from the orchard to the nearest railroad station, or other means of transportation: and the character of the roads. If the orchardist is obliged to cart his fruit a long distance, over poor roads, the cost of cartage considerably increases the cost of production. The more perishable the fruit, the closer should be the orchard to the railroad. It might pay to haul winter fruits over twenty-five miles of rough



"My Orchard pays me well."

road, but it certainly would not pay to subject the softer summer fruits to this jostling. The main points to look after in this connection is to locate the orchard where the cheapest land can be had which is adapted for the particular fruit to be grown, and where the market requirements of the fruit are satisfied.

Besides the cost of land, the attention of prospective orchardists should be directed to the important relation of the insect and disease problem to the cost of producing fruit. The orchards in cer-

tain parts of Washington are at present more liable to injury from insects and diseases than those in other parts of the state, chiefly because the climatic conditions are more favorable for their development. There is little doubt but that the more common orchard insects and diseases will ultimately spread over the entire state despite all efforts to exterminate them. Each of them, however, will probably be more serious in some sections than in others. Any prediction on this point must necessarily be more a matter of opinion than of fact, because the spread of insects and diseases is influenced by many other factors besides climate; and moreover insects sometimes become serious in localities having climatic conditions which at first were considered unfavorable for their spread. From what is known of present conditions in various parts of the state, however, the following indications with reference to some of our most important orchard pests may be recorded. The Codlin Moth will probably never become as serious in the upland orchards of Eastern Washington as it is in the warm valleys of the same section, because the season is so short and the nights so cool in the uplands that the insect does not breed as readily. There is every reason to believe that the apple scab fungus will never disfigure as large a proportion of fruit east of the Cascades as it does west of the mountains, because it needs the humid climate of the latter region for its most rapid growth. For the same reason the Black Spot Canker of apples and the Brown Rot of stone fruits seem destined to be more serious in Western than in Eastern Washington. The San Jose scale is likely to be more serious in the warm valleys than in the uplands, because the longer season of the former gives it a better chance to spread. The Peach Tree Borer seems to thrive best in the same sections. No reliable predictions can be made with reference to Pear Blight.

It will thus be seen that, in general, the indications are that the orchardists of Western Washington will be obliged to expend more in fighting fungous diseases than insects; that orchardists in the warm valleys of Eastern Washington will find insects more troublesome than fungous diseases; that orchardists in the uplands of Eastern Washington are likely to find neither insects nor diseases as serious as in the other two sections, but they cannot expect complete immunity. The fruit-growers in this and every

other section of the state must face the fact that sooner or later the spray pump will be their only safeguard from serious loss by insects and diseases. While the indications are that these will be more troublesome in Western Washington and the valleys of Eastern Washington than in the uplands, there is no reason for believing that the hill orchards will not suffer also. The upland fruit-grower will be obliged to spray, but his spraying is likely to be less expensive, because it will not need to be done as often.

The relation of the insect and disease problem to the location of an orchard is in the additional expense which preventive and remedial measures entail. Spraying appliances and spray materials cost money. Spraying takes time, and time is money. Before locating his orchard, the planter should compare different localities with reference to the probable seriousness of insect and fungous attack on the particular fruits which he proposes to grow. Other things being equal, that section in which the fruit-grower is obliged to expend least in fighting orchard pests is the most desirable; but other things are seldom equal. Usually the more essential points of fruit zones and good markets more than counterbalance the disadvantage of expensive spraying. The expense of frequent spraying is usually small compared with the advantage of having the orchard located where soil and climate are most congenial, or where a good market is easily accessible. Nevertheless the planter should give this point due weight, and should always add the probable annual cost of protecting his orchard from insect and fungous attack to his column of figures on the cost of production.

It will thus be seen that the problem of locating an orchard to best advantage is many-sided and is worthy of more careful study than it usually receives. Before locating his orchard, the careful man will compare the advantages and disadvantages of different localities with reference to the three points which have been mentioned—fruit zones, markets, and cost of production. There are always strong points and weak points in every location. One place may be close to a good market, but it cannot grow as fine fruit as a more distant location. Another may be ideal in every respect except that the price of land is high. The fruit-grower should choose the location which has the largest number of points

in its favor; that is, the one where the probable proceeds will be most in excess of the probable cost of production. He must deal in probabilities, not certainties, it is true; but a shrewd guess is the next best thing to certainty.

This bulletin is a protest against the haphazard planting which has been all too common in the early years of Washington fruit-growing, and which has given us to-day many unprofitable orchards. It is also a word of caution to those who are now planning to plant orchards in this state. The writer has unbounded confidence in the future of Washington fruit-growing. We have advantages of soil and climate such as few other states possess for producing a great variety of choice fruits. Our local markets in the cities and mining camps of this and near-by states are good now, and are constantly becoming better. Our distant markets in the eastern states, Europe, Alaska and the Orient, are broadening every year. The prospects for commercial fruit growing in Washington are good. But unless the prospective fruit-grower studies his business, and plans ahead, as any other business man would before undertaking a new venture, there will continue to be unprofitable orchards, even in the state of Washington. The mistakes of early orchardists were largely excusable because there was then no previous fruit-growing experience in this state to serve as a guide. But we have now so far added to our experience that this excuse is no longer valid. The man who is about to plant an orchard to-day will find considerable written data which will aid him in deciding on a location; but the most valuable aid of all will be the experience of the older fruit-growers of the state who have made their orchards pay them handsome profits. He will soon become convinced that their success is usually due more to close study and hard work than to luck; and he will come to prize the advice of these pioneers who have blazed the way for the fruit-growers of to-day.

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WASHINGTON STATE AGRICULTURAL COLLEGE
AND SCHOOL OF SCIENCE

EXPERIMENT STATION

PULLMAN, WASHINGTON

Bulletin 52

DEPARTMENT OF HORTICULTURE

PLANTING ORCHARDS IN WASHINGTON

By S. W. FLETCHER

1902

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INLAND PRINTING COMPANY, SPOKANE

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EXCHANGE

MICHIGAN STATE

College

MAR 22 '40

Planting Orchards in Washington.

BY S. W. FLETCHER.

In Bulletin No. 51, the location of orchards in Washington with reference to fruit zones, markets and the cost of production was considered. The present bulletin takes up those problems in the planting of orchards which arise after a location has been selected. There is a remarkable difference of experience and opinion among Washington fruit-growers on these points. It appears that this difference in experience is due mostly to the varying conditions of soil and climate in different parts of the state. This bulletin aims to analyze and classify these conflicting experiences and to place them on permanent record. The more important points discussed are orchard sites and soils, laying out the orchard, planting. The whole problem of nursery stock is considered in Bulletin No. 53. The question of varieties is of such pre-eminent importance in Washington fruit-growing that it will be considered separately in a later bulletin.

The Site,

This involves two points—the elevation, with reference to the surrounding country, and the exposure, with reference to the points of the compass.

In general, an elevated site is best. This does not necessarily mean that the orchard should be situated at a high altitude, but that it should be on land which is somewhat higher than the surrounding country. In other words, choose gentle slopes in preference to bottom lands.

The chief advantages of an elevated site are two; it usually secures good water drainage and good air drainage. Trees

cannot thrive in soil which is water-clogged or which does not dry out quickly in spring. It is a common observation in young orchards that the trees usually die out most in the low places, which are also the wet places. There are many acres of orchards in this state which are unprofitable because the trees have "wet feet." Usually the fruit-grower can secure good water drainage for his orchard by selecting an elevated site. If not, he should provide surface or under-drainage as discussed on page 8.

An elevated site usually has good air-drainage. When the sun goes down the earth cools rapidly and the air close to it becomes cool also. Cold air is heavier than warm air; therefore, it settles away from the elevations into the low places. If we ride over a hilly country on a still, cool night in early spring we notice that the hollows are colder than the hill-tops. In the morning the former may be white with frost while the latter have escaped.

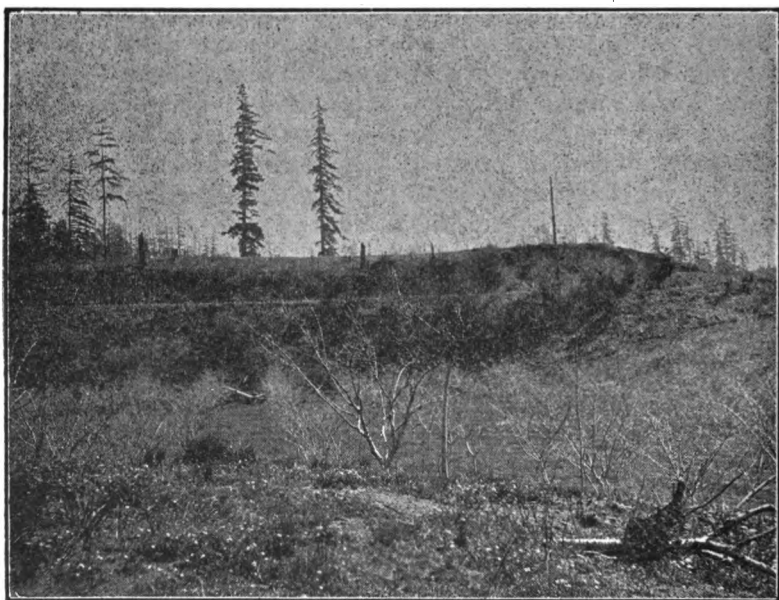


Fig. 1.—A frosty "pocket" in a prune orchard of Clarke County. The trees blossom full every year, but the blossoms are usually killed by frost.

This settling away of cold air into the low places is called air drainage, and is a most important point to bear in mind when planting an orchard. The annual loss to fruit-growers in this state from late spring frosts counts up into the tens of thousands of dollars. In other states the loss is even greater. Loss from late spring frosts may be largely, but not wholly, prevented if the orchard is planted on a slope which has good air drainage. Sometimes frosts are hard enough to injure

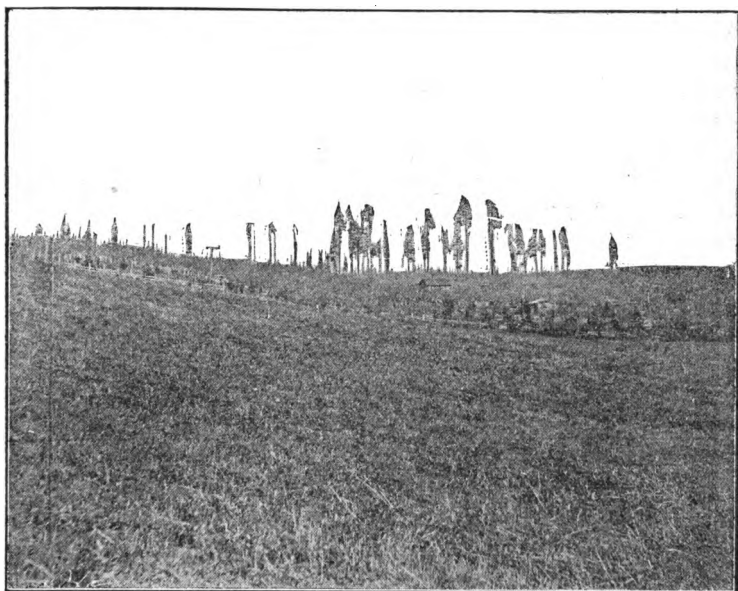


Fig. 2.—The slight "draw" through this Clarke County prune orchard has enabled it to escape serious injury from frost at blossoming time.

orchards on slopes as well as those on flat-lands; but the evidence from many orchards in the state shows that the former often escape when the latter are badly frost-injured. It is not necessary that the slope be abrupt. Usually a fall of 4 or 5 feet in 100 is sufficient to secure partial protection from frost. Above all things, the fruit-grower should avoid "pockets," or land surrounded on all sides with higher land or dense woods. When cold air settles into such places on a still night it cannot escape and a severe frost results. Fig. 1 shows

part of an orchard in a pocket. These trees have not borne a paying crop since they were planted, because the blossoms have been frosted each year. The presence of a "draw" through the orchard, like that shown in Fig. 2, tends greatly to increase the efficiency of its air drainage and its consequent immunity from frost.

On the other hand, an elevated site has several disadvantages. If the slope is quite abrupt the orchard is difficult to till, and there is apt to be considerable washing of the surface soil. Again, in some sections of the state, notably in the Palouse country, an elevated site is very windy, and the loss from fallen fruit and broken branches is often great. This objection may be largely overcome by planting on the slope opposite the prevailing wind, in sheltered coves, or by providing a windbreak. Usually, however, it is better to strike a happy mean. An abrupt and wind-swept site should be avoided as much as creek bottom. A gentle slope is better than either.

The Exposure.

If the orchard is to be planted on an elevated site the next question which comes up is the exposure, commonly called "the lay of the land." Some good fruit-growers are positive that a northern slope is best. Others are equally certain that a southern slope is best. Still others prefer a southeast cove. Which is best? It depends.

A northern slope is later than a southern slope. The trees do not start into growth as early in spring. The fruit does not ripen as early and usually does not color as well, because it has less sunshine. The soil of a northern slope is usually deeper and more moist than that of a southern slope. This is partly because the sun does not dry it out as fast, and partly because it contains more humus. Where the prevailing winds are from the southwest, as in a large part of Eastern Washington, a considerable amount of leaves, grass, fine soil, etc., is blown over the hill crest to the opposite side. When the leaves and grass decay they become humus and greatly increase the water-holding power of the soil. Because of this drifting, the northern slope in Eastern Washington is usually steeper than the opposite slope and hence is more difficult to

till. There is more surface washing. Finally, an orchard on a northern slope in Eastern Washington is largely protected from the strong southwest winds which are injurious to fruit and tree.

On the other hand, a southern slope is early. It receives a larger amount of sunshine and the trees start into growth earlier in spring. The fruit ripens earlier and is usually of brighter color and sometimes of better flavor. In the uplands of Eastern Washington, the southern slope is usually not as abrupt

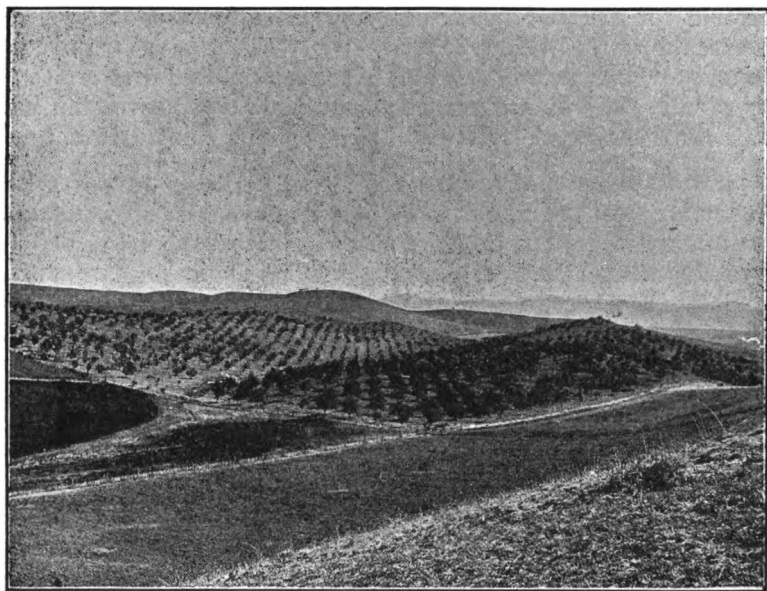


Fig. 3.—View of the Experiment Station orchard at Pullman. The main body of young trees on the left are on a southern slope.

as the northern slope and hence is easier to till. (Fig. 3.) But it is dryer, having less humus and being exposed to the full intensity of the sun. It catches the full sweep of the prevailing winds in that section and, in some cases, part of the rich, black surface soil has been blown to the other side, leaving hard clayey places which are uncongenial for fruit-trees.

It is possible to offer only general suggestions on this point. *When earliness in maturity and high color are chiefly*

desired in fruits, plant on a southern slope. This is especially true of the late maturing varieties of winter apples in some parts of the Eastern Washington uplands, where the season is usually quite short. In some seasons, Ben Davis, Walbridge, Yellow Newtown and other late varieties do not completely mature in these sections and are consequently undersized and poorly colored. Good color is the chief item in the commercial value of apples. The grower can afford to sacrifice many other points for the sake of securing this. It is the writer's opinion that in short-season localities a southern slope is usually preferable for the late maturing varieties. We can largely increase the water-holding capacity of a southern slope by adding humus and can greatly protect it from strong and drying winds by planting a windbreak; but we cannot direct more sunshine to a northern slope for the purpose of increasing its earliness.

In most parts of Western Washington a southern slope is better for most fruits, particularly for apples. There is usually no marked difference in the depth and richness of soil on the two slopes, and the heavy rainfall insures an abundance of soil moisture in almost any site. But the Coast Region fruit is apt to be of poorer color than Eastern Washington fruit, because of the humid climate and greater vegetative growth of fruit trees in that section. Orchardists in Western Washington should use every possible means for securing fruit of high color, such as pruning to a rather open top, using potash fertilizers in some cases, and planting the orchard on a southern slope where it will receive the maximum amount of color-giving sunshine.

When lateness in blossoming or maturity is desired, or when a maximum amount of coolness and moisture is necessary, plant on a northern slope. There are some sections of the state where late spring frosts seriously injure fruit blossoms, particularly of peaches, apricots, prunes and cherries. The fitful warmth of early spring days often starts the sap and swells the buds of trees on southern slopes, when trees on northern slopes are still dormant. If a severe frost follows it is apt to do considerable damage to the blossoms and sometimes to the wood. Where the early blossoming fruits are likely to be injured by late spring frosts the delay in blossoming of a few days gained by planting on a northern slope may often mean

the saving of a crop. What is gained in frost protection, however, may be offset by lateness in ripening. The planter must decide which is the more important.

In Eastern Washington most early winter and mid-winter varieties of apples, as Jonathan, Wagener, Rome, mature and color well on a northern slope. These varieties will usually keep in good condition longer when grown on a northern slope than on a southern slope. Furthermore, unless a quantity of humus has been added to the southern slope, fruit grown there will usually be of smaller size, having less moisture. This is a very important point in the unirrigated sections of Eastern Washington, especially with such varieties as Jonathan, Esopus Spitzenburg and Winesap, which tend to run undersized when there is any lack of moisture. The fruit-grower must determine for himself whether the larger size of fruit from a northern slope is more valuable to him than the higher color and earlier maturity of fruit from a southern slope. If the northern slope is not too steep it is the writer's opinion that for early winter apples it should usually be preferred. He is convinced, however, that it is possible to secure equally good results from a southern slope, with the use of windbreaks and cover crops. In some cases a sheltered southeast cove may be had which combines the warmth of the southern slope with the deeper, richer and more moist soil of the northern slope. These coves are considered very favorable sites for orchards.

Orchard Soils.

Most fruits will thrive on a great many kinds of soils, but all are more or less partial to soils of a certain character. The apple usually succeeds best on a medium clay loam; the pear on a rather heavy clay loam, the plum, prune and cherry on a medium loam; the peach and apricot on a light sandy loam. In general, the pome fruits, apples and pears, will stand heavier soils than the stone fruits, plum, prune, peach, cherry, apricot. Of these six fruits, the apple succeeds in a greater variety of soils than any other.

Not only different fruits, but also different varieties vary in their soil preferences. There is not as much definite knowledge on this subject with reference to orchard fruits as to small fruits and vegetables. This is largely because the generations

are so much farther apart in the orchard than in the garden. Men who have specialized with strawberries, for example, become familiar with the individual preferences of varieties and learn to adapt certain varieties to certain soils with remarkable results. Those who make a careful study of other small fruits and of vegetables discover similar varietal partialities. Although little attention is now given to this point in the planting of commercial orchards, undoubtedly it will be more carefully considered as our fruit-growing becomes more specialized and refined. The fact that fruits will grow well anyway in most of our Washington soils and, furthermore, that soils are so readily modified in texture and fertility by judicious handling, should not make us forget that it might be more profitable to pick out in the beginning the soil which is naturally most congenial to the variety.

Every orchard soil should possess three general characteristics:—good water drainage, good texture and a sufficient quantity of plant food. A sloping site usually, but not always, secures good water drainage for the orchard. If the orchard site has not naturally good water drainage it should be tile-drained. Box, stone or brush drains may be used if the material is handy, but a good tile drain is cheapest in the long run. There are many acres of orchards in this state, mostly in Western Washington, where an investment in tile drains would pay good interest.

The orchard soil should be in good texture; that is, it should break up fine and mellow, not hard and lumpy. Thanks to our virgin soil, we seldom need to worry about its plant-food content; but there is often good reason for being critical about its texture. In the first place, mellow, friable soils are easier to work. In the second place they hold more moisture. In Eastern Washington, both in the irrigated and unirrigated districts, remarkable differences can often be noticed in the texture and water holding power of soils, even within a few square miles. There are few places in Eastern Washington where it is not desirable to have an orchard soil retain as much moisture as possible, whether it comes from rainfall or from irrigation. The proper conservation and regulation of the water supply is the most important single factor in the management of Washington orchards. Much may be done to increase the water-holding power of soils, especially

by deep plowing, thorough tillage and plowing under stable manure or a green crop; but more is gained if the fruit-grower selects a mellow and retentive soil in the beginning.

There are very few good orchard sites in this state where the soil needs a direct application of plant food at the time the orchard is planted. Many would be benefited by the addition of one or more elements of plant food as the trees come into bearing, and a great many more would be benefited by a liberal dressing of humus-giving stable manure; but practically none need fertilizing when young above that gained by thorough tillage.

Preparation of the Land for Planting.

If possible, it is best to put the proposed orchard site into farm or garden crops one or two seasons before the trees are to be planted. Some land can be turned over and planted to fruit trees immediately, but it is better to work it a while first. Before setting out the trees the land should be plowed and fitted as well as one would for a vegetable garden. Not only does this help the trees over their first season, but it saves much digging in setting them out, which is the most expensive part of orchard planting. There are some parts of the State where the soil has a hard pan close to the surface. This should be broken up with a sub-soil plow before planting, in order that the trees may become deep-rooted and so resist drouth better. In soils which are not too clayey, fall plowing will enable the grower to plant his trees earlier in spring and so get a better start.

How Far Apart Should Trees be Planted ?

In most Washington orchards the trees are planted too close. Even the owners themselves will admit this; but, curious enough, when they set out another orchard they usually plant it pretty nearly as close as the first. There seems to be three reasons for this seeming perversity: first, a natural desire to get just as much as possible from a piece of land, just as soon as possible; second, a failure to look ahead and see what the trees will be ten years from planting; third, a misplaced confidence in some tree agent who is naturally desirous of getting as many of his trees on each acre as is at all reasonable. In some cases one and in other cases all of these reasons are responsible for the orchard forestry of this State.

Whatever may be the reasons for this condition, the results are plain enough. The writer has no hesitation in saying that Washington fruit-growers lose more money each year because their trees are crowded than from any other cause. This is true all over the State to a greater or less extent, but particularly in the older orchard of Western Washington, where trees usually grow larger than in Eastern Washington. If the owners of some of the older orchards had taken out at least every other tree ten years ago they would have a larger income from the orchards today. Even now it is not too late to mend matters. There are hundreds of these apple timber cultures all over the State bearing under-sized and poorly colored fruit and breeding Codling Moth and Scab. In some of these old orchards the trees are only a rod apart! The owners tell us that fruit-growing does not pay.

This is all wrong. Most fruit-growers are in the business for the money there is in it. If it can be demonstrated to them that when one tree is given all the room it needs for a healthy growth of root and top and all the sunshine it needs to color the fruit, it is more profitable than two or three half starved trees in the same space, they ought to be shrewd enough to see the point. The trouble is, too many fruit-growers admit this as a theory but refuse to practice it as a fact. There is most urgent need that this very common fault of close planting be corrected. It is impossible to grow fine fruit in a crowded orchard, and it is more expensive to grow it because of the greater liability of insect and fungus attack and the impossibility of thorough spraying. The advent of the spray pump has done more to increase the distance between trees in the younger orchards than any other thing. A man who has once attempted to drive a spraying rig through an old apple orchard with the trees twenty feet apart, and has tried to spray those trees, becomes an advocate and practitioner of wide planting ever afterwards.

The actual distances at which trees should be planted apart for best results varies with the location, soil, kind of fruit, and the system of pruning. Wherever the climatic and soil conditions are such as to develop a very vigorous growth the trees should be placed farther apart than where trees grow small. In the humid and equable climate of Western Washington, fruit trees make more growth than in Eastern Wash-

ington and should be planted a third to a fourth farther apart. Spy trees planted 40 feet apart in the Puget Sound country have about an equal chance with Spy trees 30 feet apart in the Palouse country.

A difference in soils makes a difference of several feet in the best distances between trees. On light and poor soils the trees may be planted several feet closer together than on havier and richer soils. Again some varieties are of upright habit and some are of spreading habit. This should be considered in planting a sommercial orchard. A vigorous, spreading grower, like King, should be put several feet farther apart than a small, upright grower like Wagener. It will pay the planter to know the habits of the varieties he proposes to plant before deciding on the distances between trees. Neither should it be forgotten that the kind of stock upon which the trees are worked often has much influence on the habit of the trees, (See Bulletin 51) and that if the trees are headed-in annually or kept in compact shape by other means they may be planted closer together.

From the sum of these many conditions each man must determine for himself the best distances to set his trees. As a general guide, however, the following distances may be suggested. The first extreme is for the dry uplands in Eastern Washington. The latter is for the rich and moist low-lands in Western Washington. A mean between the two will cover the majority of our orchards:

- Apples—30 to 40 feet.
- Pears—18 to 25 feet.
- Peaches—16 to 24 feet.
- Apricots—16 to 24 feet.
- Plums and Prunes—16 to 24 feet.
- Sweet Cherries—28 to 40 feet.
- Sour Cherries—16 to 24 feet.

Double Planting and Fillers.

Double planting in this connection means the growing of more than one kind of fruit on the land at the same time, as apples with peaches planted between the rows. In most cases the intention is to take out the peaches when the apples need

the space, and they may then be considered simply as fillers. This combination and others are used much more often in the Eastern States than in the Pacific Northwest.

Double planting has several disadvantages. Different fruits require different treatment. They are not, or should not be, pruned, fertilized, tilled or sprayed alike. It is an added inconvenience in all the various operations in the orchard to have two fruits mixed; it takes more time to get around. The tendency is, with the great majority of fruit-growers, not to take out the fillers when they are so large that they encroach upon the permanent trees.

Double planting is rarely advisable in the commercial orchards of Washington. In the East, where land is dearer, double planting is often used to advantage; but we do not need to resort to this method here. The different fruits may be mixed in the home orchard, but rarely in the commercial orchard. The fact that few soils are equally well adapted for two different kinds of fruit is usually enough to condemn the practice for commercial purposes.

Early bearing varieties of fruit, particularly the Wagener, Oldenburg, Ben Davis and Missouri Pippin apples, are coming into general use here and elsewhere as fillers between the rows of standard varieties of the same fruit. The chief advantage of using fillers is in the quicker returns from the investment because a larger quantity of fruit is secured during the early years of the orchard. This method is open to but two of the objections raised to double planting: the objection that the additional fertilizing which is made necessary may not be given; and the objection that the fillers may be allowed to remain so long that the permanent trees are injured. The latter objection is the only one which concerns us here.

There is no question whatever but that the filler system of orchard planting is a most profitable one when properly carried out; but the majority of fruit-growers will not carry it out. Through neglect or false cupidity some will not cut out the fillers at all and the orchard becomes a brush pile. Others will cut out the fillers eventually, but not until the permanent trees have been seriously weakened by the crowding of the roots. It seems to be a common notion that the roots of fruit trees usually extend out from the trunk no

farther than the branches spread. This is far from the truth. Usually they extend three or four times farther than the top. Long before the tops of the trees have met each other the roots have interlaced, and have permeated every foot of soil. Fillers should be taken out before they begin to steal nourishment from the permanent trees. This varies with soils, varieties, culture, vigor of growth, the number of trees per acre and the distance between trees; so that no definite age can be set for all places. Rarely, however, is it too wise to allow fillers to remain in the orchard longer than ten years, and eight years is more often better. If a man is sure that he can stand it to put the ax into some of his best and most profitable trees when they are still in the prime of their life and apparently are not crowding the permanent trees, let him plant fillers; and strengthen himself the meanwhile for the day of temptation which is in store for him. Otherwise the old-fashioned way is better. There is no disparagement of fruit-growers as a class in saying that the majority had better let fillers alone. The fruit-grower who has brought up a tree from a slip of a yearling to full bearing and does not hate to cut it down is a rare man. It is as much this natural reluctance to destroy the object of his care as the grasping desire for one more crop which prevents the fruit-grower from taking out the fillers when he should. A man should never plant fillers until he has a pretty clear understanding with himself when they should be taken out.

Laying Out the Orchard.

There are numerous plans upon laying out an orchard and locating the positions of the trees. One of the very best is the hexagonal plan. This is coming into general use in the state and is supplanting all others, including the old way of planting in the corners of squares and the alternate method. By the hexagonal plan more trees can be grown on an acre of land than in either of the other two, and they are distributed more equally over it. Fig. 4 illustrates the main ideas of the hexagonal plan.

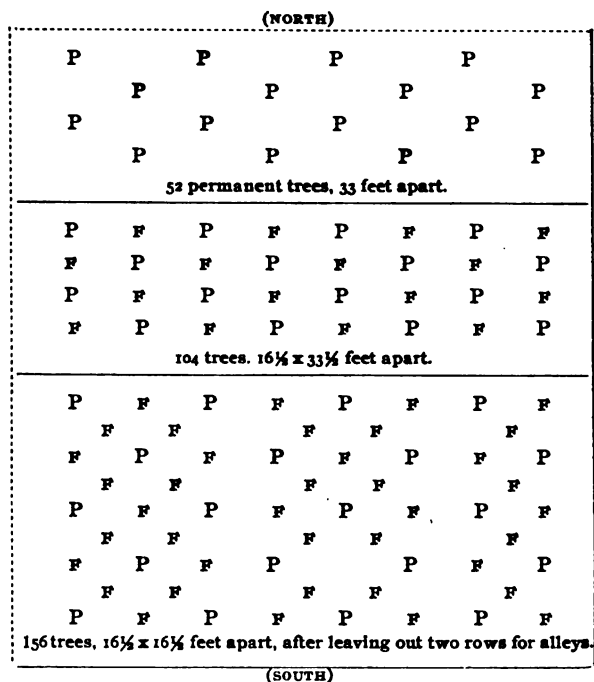


Fig 4. Hexagonal plan. Adapted from "The Principles of Fruit-growing," Bailey.
The permanent trees are designated by the letter P; fillers by the letter F.

For laying out an orchard on the hexagonal plan get two boys, a hatchet and as many wooden stakes, twelve to eighteen inches long and of uniform size, as there are to be trees in the orchard. Take two small wires and make a loop in each end large enough to slip over the tops of the stakes; or, what is better still, attach a ring to each end of the wire. Small wire is better than large wire because it does not kink as bad. The length of each wire from center to center of the rings should be exactly the distance which it is desired to have the trees apart,—say two rods or thirty-three feet, which is about right for apples in most parts of Washington. Proceed to the orchard site and, by measuring and sighting, place a row of stakes along one side to mark the exact position of the first row of trees. Be sure to get the stakes exactly thirty-three feet apart to the inch, get them in a bee-

line, and get the row square with the rest of the orchard area. Let each boy take the end of one wire and the man the ends of both, also the hatchet and a quantity of stakes. One boy slips the loop of his wire over the top of the first stake and down to the ground. The other boy slips the loop of his wire over the second stake in like manner. The man then pulls the two wires taut from his end until the loops of both are together, the whole forming the letter V. A stake is driven down at the point of the V, the first boy removes his wire to the second stake, the second boy removes his to the third stake, the man moves along to a point midway between the second and third stakes and marks the position of the next tree in the same way;—and so on to the end of the row. Returning, the loops are put on adjoining stakes in the second row just marked and the third row of stakes is set. Thus the stakes in the first and third rows are opposite each other and the stakes of the third row are midway between the two and alternating with them.

On comparatively level ground an orchard can be laid out on the hexagonal plan quicker and straighter than in any other way. With a careful man to drive the stakes the rows should be as straight as those made by the most careful sighting. If the orchard site is quite hilly it is necessary to glance each way before setting the stakes in order to correct the inequalities of measurement made by the irregular contour; or the wire may be held at a level and the stakes dropped into place from above.

In case fillers are used they may be placed in the position indicated in Fig. 4. When the fillers are removed the permanent trees all stand thirty-three feet apart, although the rows are but twenty-eight feet apart. In any case it is wise to make a detail plan of the orchard on stout paper showing which are the permanent trees, which the fillers, and locating the different varieties. Most of the confusion about varieties in this State is caused by the neglect of orchardists to keep some permanent record of their planting. Never trust labels. They blow off, rust off and are stolen. Make a map of the orchard with ink at the time of planting and record on it changes or additions.

Spring or Fall Planting.

Like most of our much mooted horticultural questions, the best time to plant fruit trees in this State is not the same in all sections, but depends on many things. The most important of these are: (1) The character of the orchard soil, (2) the character of the trees, (3) the severity of the winter, (4) the relative convenience of the two seasons.

It is unwise to fall plant trees in any part of the State on soils which are persistently wet during the winter. Fall planting on bottom lands especially should be avoided. There is always a much greater liability of trees being winter injured, either in the tops or roots, when fall planted on poorly drained soils than when fall planted on well drained soils. Success in fall planting depends largely on the ability of the tree to become partially established in the soil before winter sets in. This is impossible in very wet soils. Several instances of poor results from fall planting have been called to the attention of this Experiment Station during the past two years. In every case the apparent reason was that the trees were planted on poorly drained land. On the other hand, hundreds of acres of orchard have been successfully fall planted on well drained soils in this State during the same period.

The character of the trees has much to do with the success of fall planting. As one would naturally expect, thrifty and well-matured stock comes through the winter better than weak or poorly-ripened stock. Nurserymen encourage fall planting for good reasons of their own and make an effort to get their stock into shape for early fall delivery. In some irrigated nurseries the trees are forced to a sappy over-vigorous growth by an excess of water in order to get a large tree by early fall. In more than one case these trees have been seriously winter injured after fall planting, even on well drained soils; particularly in the uplands of Eastern Washington. If fruit-growers in the latter region purchase stock from irrigated nurseries, it is safer to plant it in the spring.

Another nursery practice which has an important bearing on fall planting is "stripping." In order to check the growth of nursery trees, and ripen them for fall delivery, nurserymen sometimes strip off all or part of the leaves from the trees a few weeks before it is desired to sell them. As a result, growth is checked immediately, not gradually, as when

the trees are allowed to ripen naturally with all the leaves on. It has been the experience of many that "stripped" trees are less hardy and have less vitality than normally ripened trees; and, when planted in the fall, are less likely to survive the winter. Some fruit-growers have fall planted stripped trees successfully, but it is undoubtedly safer to insist on having normally ripened trees for fall planting. The nurseryman should be instructed on this point when placing an order.

Fall planting is more likely to be successful with the hardier fruits, apples and pears, than with peaches, cherries, plums and apricots. There are very few places in this State, except in Western Washington, where it is wise to plant peaches and apricots in the fall. Cherries, plums and prunes may often be planted in the fall if the soil and other conditions are favorable. The sour cherries can be fall planted better than the sweet cherries. Apples and pears may be fall planted in almost any part of the State, when the right conditions are present.

In some cases an important point in favor of fall planting is that the orchardists may have more time then to do the work. Spring is or ought to be a very busy season with the fruit-grower. In the fall he may be able to take more time and do better work, for the planting of trees is the one operation above all others which ought not to be slighted. Moreover the weather is apt to be more settled in the fall than in the spring.

Fall planting is thus a matter of judgment, not of rule. In some cases it is very advisable, in other cases very unadvisable. The mild winters of Western Washington usually insure success for fall planting in the well drained soils of that section; not only of apples and pears, but even of the more tender stone fruits. In fact, so equable and moist is the climate there that many growers plant trees with success all through the winter, even in January and February. In Eastern Washington it is necessary to exercise greater caution. Apples and pears may often be planted in the fall to advantage, plums, prunes and cherries sometimes, peaches and apricots rarely. Most peach growers in the irrigated valleys of Eastern Washington prefer spring planting for the reason that their soils are usually light and are likely to dry out in winter unless irrigated. The exact time in the fall when it is best to

plant varies with the locality and with the season. In some cases the middle of September is none too early, in others, trees may be fall planted as late as the middle of November. As a rule, the first to the middle of October is the safest. If the rains do not come until later, wait for them. A long moist fall is favorable for fall planting and a cold, open winter unfavorable.

Whether one plants in the fall or in the spring, it is better to buy the trees in the fall. A better selection of stock can be had in the fall than in the spring. The nurseryman digs his trees in the fall and heels them in over winter in the cellar or out of doors. The fall buyer gets the pick of the lot if he is shrewd. The spring buyer takes what is left. Nurserymen encourage fall planting because it lightens part of the spring rush.

Treatment of the Tree at the Time of Planting.

In removing the young tree from the nursery a large part of the root system is cut off. The exact amount depends on the variety, the soil and the age of the trees. The richer and mellowier the soil the less will be the distance which the roots must travel in search of food and the greater will be the proportion of roots saved in transplanting. Some varieties have a more compact root system than others. Finally, the younger the tree the greater will be the proportion of roots saved in transplanting. This is one reason why yearling trees are commonly preferred to older trees for orchard planting in this State.

In order to meet this loss of roots and re-establish the balance which normally exists between the top and the roots, it is customary to cut back the top at the time of planting in proportion as the roots have shortened. With yearling trees, which are usually unbranched, except, in the case of peaches, a fourth to a third of the top is removed, depending on the condition of the roots and the height at which it is desired to start the head. If two-year-old trees are planted, which are almost always well branched, usually it is best to cut out all branches which are not needed for the frame-work of the tree and to shorten the others about a third. Some of our best growers, however, prefer to leave on all of the branches at the time of planting and to take out the superfluous ones gradually

during the next three years. This method has given good results in those parts of Eastern Washington where a stocky, low-headed tree is most desired. Peaches may be trimmed to a whip or the branches shortened to two or three buds. Both methods are satisfactory; some growers prefer one and some the other. The only exception to the general rule that the tops of trees should be cut back at the time of planting is when they are fall-planted in the colder parts of Eastern Washington. There it is usually better not to cut the top at all until the following spring, as the pruned branches are apt to dry out and winter-kill. For all pruning at the time of planting a knife is better than the pruning shears because it makes a clean, sharp cut which heals over better than the crushing cut of shears.

In common orchard practice the treatment of roots at planting time consists simply in cutting off the broken roots and the bruised ends. Some of the most successful fruit-growers in the State, however, thin out the roots considerably so that they will not chafe one another and will be equally distributed on all sides. They believe that this results in a more uniform and vigorous growth. It is but a step from this practice to the "Stringfellow system" of root pruning, in which all the roots are shortened to mere stubs a few inches long and the top is cut back to correspond. Without going into details of this much-discussed method, it may be said that it seems to have little value in the fruit-growing of this State; except, possibly, with peaches in the irrigated sections, and then only in a modified form. It has been used very successfully with peaches in the worn-out cotton fields of the South and has found some favor in other localities; but throughout the Northern States it has been reported on unfavorably with few exceptions. In 1898 several trees each of over forty varieties of apples, were planted on the Experiment Station grounds at Pullman, part being root-pruned according to the Stringfellow system and part being treated in the ordinary way. In the spring of 1902, when the trees were removed, it was found that about 10 per cent. of the root-pruned trees were dead. Most of those which were alive were still considerably smaller than the others. With some varieties, however, there was no appreciable difference. In no cases were the root-pruned trees superior to the others. Taking into

consideration the fact that many more root-pruned trees died than the unpruned, and that the majority of those which did grow had not caught up with the others at the end of four years, we are justified in concluding that the old way is still the better.

The stub-root system certainly does give a much more handsome and more evenly distributed root system than the

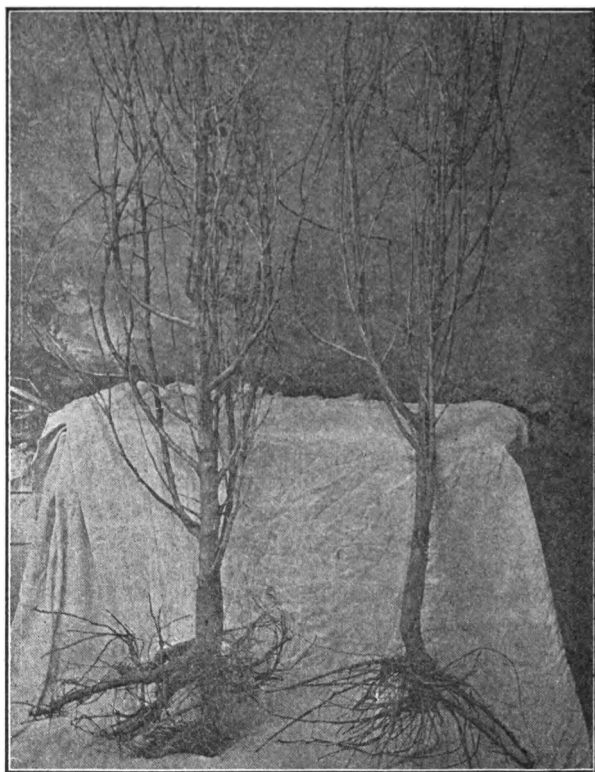


Fig 5.—Typical results with Stringfellow root-pruning. Root-pruned tree on left, unpruned on right. Notice the difference in the root systems and in the size of the top.

other, in some cases. These exceptions only prove the general rule that it is safe to leave the roots on, especially if the soil is at all hard or poor. One advantage claimed for the stub-root

pruning is that it results in a deeper rooted tree than the other. This claim was not verified in our trial. Typical results in top and roots are shown in Fig. 5.

The Stringfellow system of root-pruning, while not adapted to Washington conditions in its extreme form, has yet been of value in demonstrating that it is not necessary that all the roots be carefully preserved in transplanting. The writer believes that a judicious thinning of the roots of all fruit trees at the time of planting, particularly when they crowd each other, is a good practice; and he is ready to believe that a modified system of root-pruning may sometimes be used to advantage on the lighter soils of the irrigated valleys in Eastern Washington. It should be understood, however, that root-pruning is a special practice for special cases. The general rule is, leave most of the sound roots on at the time of planting.

Planting.

When ready for planting, the trees should be brought from the nursery or cellar and heeled in on some convenient spot in the orchard. As trees are needed for planting take a bunch from those heeled in and throw a wet burlap sack over the roots while carrying them around the orchard. Never let the sun strike directly on the roots and never leave the trees out of the ground longer than is absolutely necessary. In some sighting methods of laying out an orchard, holes may be partly dug by turning a deep furrow along the line of the row, but in the hexagonal plan this cannot be done nor is it altogether desirable. What we have in this case is a field of stakes, each stake marking the exact position where a tree should go. The next step is to plant the trees just where the stakes are set. This should be done with the aid of a planting board. It is not necessary to have this board over four feet long and three inches wide and it should be made of one and one-half-inch material. There should be a square notch at each end into which fits a small square peg and another exactly in the middle. Notches in the end are preferable to holes bored several inches from the end, because the board can be easily kicked away with the foot instead of being swung on a stake pivot, as is sometimes recommended. Place the middle notch against the stake, drive a peg against each end notch, kick away the planting board, pull up the stake, dig

the hole and replace the board against the peg. The tree may then be set against the middle notich and no sighting will be



Fig. 6.—Planting. Use the planting board, and lean the tree a little to the wind.

needed. (Fig. 6.) After the tree is set pull up the two pegs and use them in setting the next tree.

The hole should be dug deep enough to allow the tree to be set a trifle deeper than it stood in the nursery and large enough to accommodate the larger part of the roots without twisting. The harder the digging the bigger should be the hole. Some fruit-growers even go so far as to blow out each hole with a dynamite cartridge when there is an impervious hard-pan close to the surface through which the root cannot penetrate easily. This gives excellent results when the site has a good fall in one direction, but when it is nearly level these holes through the hard-pan often catch all the surface drainage and the trees are drowned out. Do not set the trees either in dead-furrows or in back-furrow. In diging, put the rich surface soil to one side and use it around the roots. Cut out

all broken roots and thin out the crowding roots. Throw a little good black soil in the bottom of the hole, set the tree in, spread the roots out as naturally as possible, and shake the black dirt down among them. Be sure there are no holes left around the roots, particularly underneath the crown or fork of the roots. Use the fingers for poking dirt in between the roots and joggle the tree up and down a few times. Then fill up the hole about half full and tramp down firmly, using the heels freely. Fill the hole, tramp again and finally before leaving throw a few shovels-full of loose dirt on top to check the evaporation of soil moisture. In the rich and moist valley soils of Western Washington, where the winters

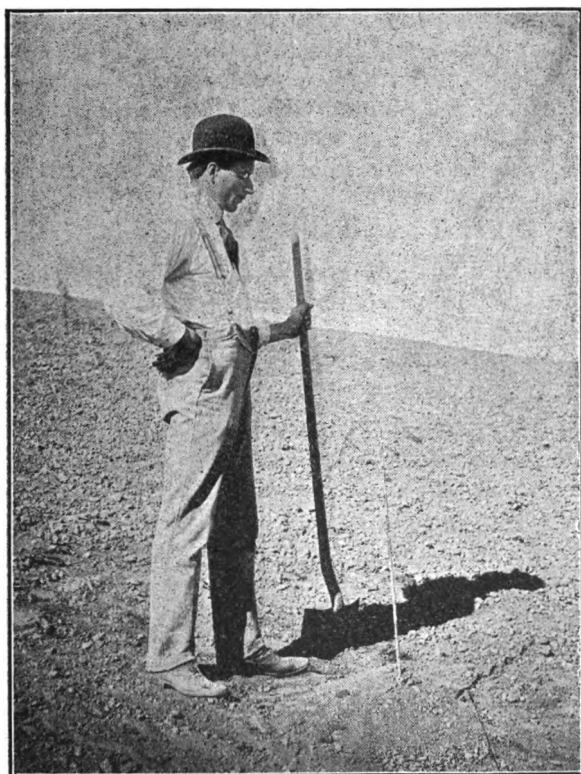


Fig. 7.—Planting. Cut off the top to meet the loss of roots, and bank soil around the base of the tree, if planting in the fall.

are mild and wet, it is often advisable to set the trees quite shallow, if planted in the fall, sometimes with only four or five inches of soil covering the roots. In the hillside soils of the same sections, however, set the trees at full depth. In clay soils do not stamp the soil around the roots hard enough to cake it. Light soils can hardly be stamped too firmly around the roots. If manure is used, put it around the tree after it is planted, not around the roots, especially if it is fresh or strawy. Fresh manure burns the roots and strawy manure dries out the soil.

Leave the tree straight, except in the very windy sections of the state where it is well to lean it fifteen to twenty degrees in the direction of the prevailing wind. If planting is done in the fall the tree should be banked up with dirt for at least a foot high around the base, to throw off water and steady it in the wind. (Fig. 7.) A good mulch of manure is also excellent around fall planted trees. The main point in planting is to take time enough to do a good job. It does not pay to be obliged to re-set trees because of careless planting.

POINTS.

1. Usually a slightly elevated site is better for an orchard than low land, because it has good water drainage and good air drainage.
2. Where earliness in maturity and high color are chiefly desired in fruits, plant on a southern slope.
3. Where lateness in blossoming or maturity is desired, or when a maximum amount of coolness and moisture is needed, plant on a northern slope.
4. Each fruit and even each variety is partial to soils of a certain character. The fruit-grower should study these varietal preferences.
5. As a rule, the fruit trees in this State are planted much too close for the greatest profit. The location, the soil, the kind of fruit and the system of pruning, should be considered in deciding this point. In Eastern Washington fruit trees may be planted a third closer than in Western Washington.
6. Plant each kind of fruit by itself in the commercial orchard.

7. The use of fillers is to be recommended if they are taken out at the right time.

8. The hexagonal plan of planting an orchard is, all things considered, the best for general use in this State.

9. Trees may be planted in the fall with success only when the soil is well drained, the trees well matured, and the winter mild. Fall planting is safer in Western Washington than in Eastern Washington.

10. The Stringfellow system of root-pruning is not adapted for orchard planting in this State, except in a modified form.

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